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NAVAL POSTGRADUATE SCHOOL MONTEREY, CALIFORNIA



THESIS

INTRANETS

by

James Charles King
and
William Paul Mizerak

September 1996

Principal Advisor:

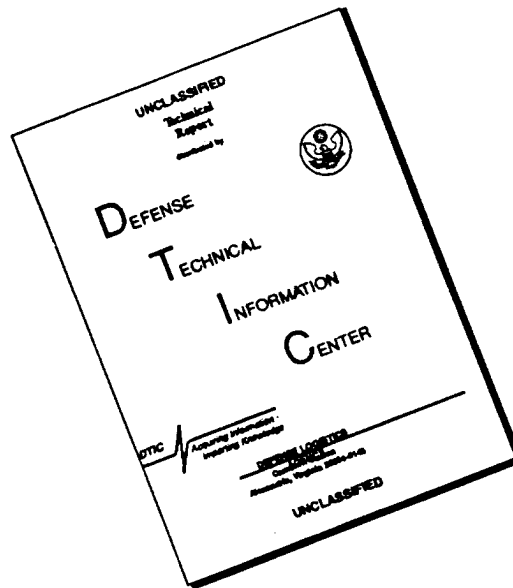
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1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE September 1996	3. REPORT TYPE AND DATES COVERED Master's Thesis		
4. TITLE AND SUBTITLE INTRANETS		5. FUNDING NUMBERS		
6. AUTHOR(S) King, James C., and Mizerak, William P.				
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Naval Postgraduate School Monterey CA 93943-5000		8. PERFORMING ORGANIZATION REPORT NUMBER		
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)		10. SPONSORING/MONITORING AGENCY REPORT NUMBER		
11. SUPPLEMENTARY NOTES The views expressed in this thesis are those of the author and do not reflect the official policy or position of the Department of Defense or the U.S. Government.				
12a. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release; distribution is unlimited.		12b. DISTRIBUTION CODE		
13. ABSTRACT (maximum 200 words) The purpose of this thesis is to develop a prototype Client-Server application that can be used by selected Naval Postgraduate School staff-members to coordinate meeting agendas and travel plans. A prototype application that can be implemented and deployed on an organizational network was designed and developed using commercially available tools. The thesis also addresses the current computing problems confronting this institution and the reasons why corporate America is embracing Web-based intranet technology; it will also examine why a Web-based intranet is a viable solution for many of the computing problems facing this organization. Additionally, we examined other applications that can be developed and deployed on an intranet at the Naval Postgraduate School. Finally, we explore the renowned intranet at Sandia National Laboratories and explain which factors played the most significant role in the success they have achieved with intranet technology at their organization.				
14. SUBJECT TERMS Intranets, Hypertext Markup Language, Sandia National Laboratories, Cross-Platform, TCP/IP Networking		15. NUMBER OF PAGES 100		
		16. PRICE CODE		
17. SECURITY CLASSIFICATION OF REPORT Unclassified	18. SECURITY CLASSIFICATION OF THIS PAGE Unclassified	19. SECURITY CLASSIFICATION OF ABSTRACT Unclassified	20. LIMITATION OF ABSTRACT UL	

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INTRANETS

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Submitted in partial fulfillment
of the requirements for the degree of

MASTER OF SCIENCE IN INFORMATION TECHNOLOGY MANAGEMENT

from the


NAVAL POSTGRADUATE SCHOOL
September 1996

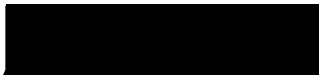
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ABSTRACT

The purpose of this thesis is to develop a prototype Client-Server application that can be used by selected Naval Postgraduate School staff-members to coordinate meeting agendas and travel plans. A prototype application that can be implemented and deployed on an organizational network was designed and developed using commercially available tools. The thesis also addresses the current computing problems confronting this institution and the reasons why corporate America is embracing Web-based intranet technology; it will also examine why a Web-based intranet is a viable solution for many of the computing problems facing this organization. Additionally, we examined other applications that can be developed and deployed on an intranet at the Naval Postgraduate School. Finally, we explore the renowned intranet at Sandia National Laboratories and explain which factors played the most significant role in the success they have achieved with intranet technology at their organization.

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I. INTRODUCTION AND BACKGROUND

A. INTRODUCTION

An intranet is simply the use of World Wide Web technology within an organization to enhance communication, collaboration, and information distribution. Web browsers are employed as "universal clients" that access data and information stored on organizational computers. Web servers are the medium through which information travels.

Intranets are a direct result of the interest and explosive growth seen in the Internet and the World Wide Web. This phenomena is a relatively recent one, having emerged within the past year. Nevertheless, it is having a profound impact on the way people communicate within organizations and, as a result, is affecting the very fabric of organizational culture. The terms used to describe the evolving concept of an 'Intranet' have included enterprise computing, corporate Internetwork, corporate Internet clone, internal Internet, private Internet, intranet working, and internal web (site). However, since these terms are rather broad and have different meanings to different individuals, they have not really served to clarify the issue. (Stucker, 1996) In his definition of an intranet, Michael Carroll has addressed the characteristics of the Internet. In his opinion, the openness of the platform and the social aspects resulting from this openness, results in a depth and breadth that is something different from the information systems that we have experienced to date. These Internet attributes are essential ingredients in his rather succinct definition of an intranet as a "corporate Internet clone that has been placed inside a private organization." (Stucker, 1996)

The adaptation and implementation of this technology by industry has been recent, swift, and broad, as organizations have quickly recognized the benefits to be

realized from this new organizational 'network.' Presently, two-thirds of all large corporations either have an internal Web server installed, or are considering installing one. (Thyfault, 1996)

The explosive growth in this market is indicative of the potential hardware and software market developers and vendors foresee. According to analysts, Web servers, the heart of corporate Intranets, presently represent an annual business of \$476 million, with sales anticipated to grow to \$1 billion by the year 2000. Sales of intranet software will hit \$142 million this year, \$488 million next year, and \$4 billion in 1997, says forecaster Zona Research Inc. (Cortese, 1996) Internal Web Sites already outnumber external ones. Although exact figures are not available, industry analysts believe that organizations will soon deploy ten times as many internal Web servers as external ones. (Thyfault, 1996)

B. BACKGROUND

The World Wide Web is a collection of HTTP servers on the Internet. It is based on concepts that were developed at the European Particle Physics Laboratory (CERN) in Geneva, Switzerland, by Tim Berners-Lee and his colleagues. The Web uses hypertext to link together a web of documents that may include text, graphics images, sound files, video files, and other formats such as Sun MicroSystem's Java. Hypertext is an intuitive way to navigate from one document to another, and allows the traversal of documents in a non-linear manner in the search for information.

The World Wide Web is an entirely Internet-based concept founded in part on existing services such as Gopher and FTP, but primarily on a new protocol, HyperText Transport Protocol (HTTP). HTTP provides users access to the files that make up the Web. These files may be in many different formats, such as text, graphics, video, and audio, but the most common format is HyperText Markup Language (HTML). HTML is the standardized page description language used for

creating Web pages; it provides basic document-formatting capabilities, and allows the user to specify hypertext links to other servers and files. (Chapman & Zwicky, 1995)

C. INTRANET ADVANTAGES

The rapid growth of intranets is not without reason. Intranets are fast, they work, and they scale well - basically, the same advantages that led to the dominance of Transmission Control Protocol/Internet Protocol (TCP/IP). After all, the World Wide Web is a great deal more complex than any one organizational network, and it seems to satisfy an enormous number of users. (Millikin, 1996) Intranets provide a cost-effective method of sharing organizational information within an existing network architecture at minimum cost, effort, and time. The reasons for implementing an intranet are varied and numerous; they include:

1. Ease of Use

The World Wide Web, which uses (HTML) as its foundation, produces a very intuitive point-and-click interface, hence a very simple way for the user to navigate through the system and retrieve information or data. This user-friendly environment all but eliminates the training costs associated with learning other proprietary software products.

2. Cross Platform Functionality

TCP/IP has proven superior in tying together diverse computer operating systems - such as Windows, Macintosh, or Unix - into one seemingly transparent network. This functionality permits any user, on any machine equipped with a web browser, to have access to any information stored on any of the organization's servers. "The Web allows a diverse population to access applications and documents across platforms and across sites in a way that probably wouldn't be possible anywhere else

except in a small company," says Tracy Walker, senior technical staff member Sandia National Laboratories. (Buchanan, 1995)

3. Pull vs. Push Model

Web-based applications, unlike traditional applications, are based on users tapping into information when and where they need it, permitting them to personally retrieve information in a much quicker and more efficient manner. "It's based on the idea of making information broadly available to allow people to do their jobs," says Robert Walker, CIO at Hewlett-Packard. (Moad, 1996)

This technology represents a paradigm shift and a fundamental change in organizational culture. This is because the directional control of the information flow has shifted from the information creator to the user. If users are able to easily retrieve the information they need when they need it, there is no longer a need for that information to be sent to them just-in-case by the information creator. Creators must retrain themselves to publish material without distributing it. Users must take more initiative in determining their information needs. They must also play a more active role in satisfying these needs by learning to efficiently acquire information for themselves. (Tellen, 1995)

4. Organizational Freight Hauler

The Web is ideally suited to the movement of large amounts of information within an organization on demand. Since it has been estimated that, on average, 18 percent of the information disseminated today will be out of date within 30 days, an organizational intranet is an ideal way to ensure that only the most current information is available. Additionally, this medium would preclude the costly publishing and mailing charges that organizations encounter today, and eliminate the frequent problem of version control inherent in large organizations situated over large geographic areas. (Process Software, 1995)

5. Enhances Productivity

Since Web Pages are easy to produce and maintain, and do not require a knowledge of computer programming, the Web servers can be easily managed by the "content creators." This simplicity serves to further enhance the productivity of the entire organization in four ways.

First, this shift in responsibility helps reduce development costs by enabling the Information Systems professionals to concentrate their efforts on monitoring the organizational computer systems instead of maintaining server content. (Process Software, 1995)

Secondly, the information being published on departmental homepages should greatly reduce the number and length of routine inquiries that unfortunately reduce each worker's productivity. Intranets permit organizational members to devote a larger percentage of their workday performing their regular duties.

Thirdly, the creation of departmental homepages requires that each department define their role and in the process "justify their existence" within the organization. This un-intended benefit was realized at Silicon Graphics in Mountain View, California. The redefining of departmental roles and missions within the corporation enhanced the productivity of the entire organization.

Lastly, but perhaps most importantly, HyperText is a medium that actually enhances creativity by promoting a free-wheeling, human thought process. This format is compatible with the human thought process which is also non-linear, and contrasts with the linear cause and effect relationships in which humans tend to frame all problems.

6. Low Cost to Implement, Operate, and Maintain

Initial Web startup costs and commitments are very low, requiring minimal investment and training. Additionally, depending on the size of the intranet

implemented, only a minimal dedicated staff may be required to maintain the system. For example, SGI has an Information Technology (IT) department with 150 people. Only six of those IT personnel are dedicated to working on the SGI Intranet, which consists of over 900 servers. The rest of the IT personnel serve in more traditional roles.

Most of the work done generating the content on SGI's Intranet is done by the users. Home Pages and other documents that will be published on the intranet can be easily created by migrating existing documents to HTML with one of the many Web authoring and editing tools currently on the market. A Web Server consists of a computer with an operating system and Web server software. The Web server software provides the functionality required to manage the organization's Web, and is also capable of integrating existing internal databases and backroom applications into the organizational intranet. In order for the server to communicate with the clients, a LAN Card and a TCP/IP stack is required on each client machine. Additionally, each client will also need a commercial browser software package such as Netscape, NSCA Mosaic, or Microsoft's Internet Explorer to access information on the Web. (Process Software, 1995)

7. Extends Existing Infrastructure

Rather than discarding older systems, intranets make it possible to incorporate older legacy systems within an organizational network. One of the greatest potential growth sectors in the intranet market is in the development of software to seamlessly access and query information and data maintained in older mainframe-based 'stovepipe' legacy systems, and in using these mainframes as intranet servers for an organization. Additionally, personal computers with relatively old processors, such as 286s, and 386s, can have their useful lives extended with the implementation of a TCP/IP stack, which then makes them viable platforms in an organizational network.

8. Easy Access to "Persistent Information"

The term "Persistent information" was coined by Jim Seymour of PC Magazine, and is defined as information that is needed now, can be located quickly and easily, and referenced for some unknown period of time. Instead of maintaining information in many different formats and mediums, and having to address the problem of version control, an intranet permits the maintenance of a single copy of that persistent information in one place, where it can be easily updated and kept accurate, accessed electronically, 24 hours a day, from anywhere in the world. (Seymour, 1996)

D. IMPLEMENTATION ISSUES

Some of the concerns that should be considered prior to implementing an Intranet architecture within an organization include the following:

1. Web Addiction

Although the tremendous volume of information available on the World Wide Web represents its greatest attribute, it also represents an enormous opportunity for employees to spend an excessive amount of time in pursuit of fruitless and unproductive 'Web Surfing.' For those that are not computer literate and not familiar with the World Wide Web, this affliction and subsequent addiction can be particularly adverse.

Currently, there are several studies being conducted, including one that has been completed by Silicon Graphics, to compute the Return-On-Investment (ROI) to be realized from implementing a corporate intranet. The Silicon Graphics study did not address the Web addiction issue, which was no real surprise since the company promotes personal creativity and does not attempt to stymie personal initiative. If unsanctioned Web Surfing becomes a major concern in an organization, however, a firewall that restricts or limits access to specific Web sites can be helpful in limiting

this potential loss in productivity. Another perspective that has been advanced regarding this concern is that the novelty of this technology actually serves to accelerate a user's proficiency in navigating the system, thus making them efficient much more quickly than would a typical proprietary training program.

2. Security

Perhaps the greatest concern with respect to any organizational network is the issue of security. Intranets are no different. Unauthorized users must be kept out of an organization's mission critical data. In order to accomplish this goal, organizations employ an Internet firewall. An Internet firewall is a set of hardware components - a router, a host computer, or some combination of routers, computers, and networks with appropriate software. (Chapman & Zwicky, 1995) These physical devices protect the network systems and data, and offer the following advantages over other security methods:

a. A firewall is the focus for security decisions, and represents a single choke point through which all inbound and outbound traffic must pass. The fact that all traffic must pass through this point represents an enormous amount of leverage to network security because it allows the organization to concentrate its efforts at this point.

b. A firewall can enforce the organizational security policy by allowing only services that have been condoned by the organization for specific users to pass in and out of the organization.

c. A firewall can efficiently record all Internet activity. As a result of all traffic passing through the firewall, it provides an ideal location from which to monitor the system and record information regarding system use and misuse.

d. In order to verify the authenticity of messages received from remote users, digital signatures - using the Rivest, Shamir, and Adleman (RSA)

public key encryption algorithm - have become a viable and rather common method of ensuring the authenticity of the message originator. Currently, there are several products available on the market including the popular Pretty Good Privacy (PGP), and Verisign products, which both use RSA Public Key Encryption.

3. Lotus Notes

"Isn't an Intranet an el cheapo version of Lotus Notes? Is it going to kill off Lotus Notes?" These are two questions frequently heard by Jim Seymour of PC Magazine. Today his answer to both of these questions is "No." In fact, he feels as do several different authors, consultants, and corporations including IBM, that intranets and Lotus Notes can complement one another in an organizational network. Presently, Notes is a more robust, functional application than an intranet, which provides a complete platform for all Internet applications, including mail, discussions, security, and World Wide Web Applications. (Kluge, 1996) Like the Web, Lotus Notes is based on the concepts of a rich, document-oriented database, fielded forms, and document linking, and is therefore ideally suited as a development and deployment platform for World Wide Web applications. What had been missing in Notes previously, but has been incorporated into the latest released version, was direct support of World Wide Web protocols. This marriage of Notes with Internet protocols represents an enormous opportunity for Lotus, its customers, and its partners by leveraging the mature groupware functionality of Notes to reach non-Notes clients via Internet protocols. (Kluge, 1996)

Today Lotus Notes has no equal as a business tool, but there are some factors regarding Notes that should be taken into consideration, namely its higher cost - \$150 per desktop (instead of the typical cost of \$20 or less for an Internet browser) - and the proprietary nature of the product, as opposed to the "open" design of the World Wide Web. (Ziegler, 1995) However, as more diverse and functional applications

are developed for intranet web sites, the differences between the two implementations will certainly narrow with time.

4. Transaction Processing

Presently, the Web is still not suited for "mission-critical" applications such as order processing or accounting. The basic problem is that Web Servers were not designed for high-speed, reliable transactions. However, this may not be true for long as corporations such as IBM, Digital Equipment, Netscape, and Sun Microsystems, as well as a variety of new firms, focus their energies in this market segment. Because of the relative youth of intranet technology, most corporations are electing to do business with the established companies. John Whiteside, head of IBM's Global Network, hopes to translate that sentiment into a billion dollars in business this year. "Every single one of our customers is asking for something in terms of an intranet" he says. (Cortese, 1996)

5. Response Time

Response time is a function of bandwidth and the size of the file being transferred. Additionally, any requests from a Web browser that necessitate the operation of another back-end application, such as a database Structured Query Language (SQL) query, will inherently slow the response time for a user. Bandwidth is normally not a constraint that limits the functionality of an intranet except for those users who must log in remotely and therefore contend with general Internet traffic bottlenecks. Typically, a high-speed Internet connection accesses the Web at 1.5 Mbps using a T1 line, whereas an internal connection increases the capacity tenfold or more. (Kaneshige, 1995) The rich multimedia applications, including video-conferencing, that are available today on organizational intranets are good examples of the applications that will be available with the high-bandwidth Internet of the future.

One way that Silicon Graphics has reduced the access time for a remote user with limited bandwidth is to provide individuals with an option to download only the text from each HTML page. This text-only option permits information to be retrieved without the delay inherent with graphics intensive HTML pages. Since intranets are for internal use only, some organizations have taken the position that flashy graphics, audio, and video are for the customers and not the employees. These institutions are only interested in presenting the requested information in a fast and efficient manner. Where bandwidth is an organizational constraint, the functionality of an intranet can still be preserved by eliminating imbedded audio, video, and graphics typical of most World Wide Web pages.

6. Business Rules

Any business rules in a database-driven Web application, whether for internal or external use, are normally enforced by the underlying DBMS. For example, Oracle's Web Server works directly with the Oracle database using native Oracle drivers. Any errors in data input that can be dealt with by the Oracle DBMS can be transmitted to the user via the Web browser. Edit masks, required fields, data types, and other rules are enforceable, but are usually only enforced after the "Submit" button is pressed on an HTML form. Some of the more sophisticated features that are available with traditional database front-ends have not yet been implemented using web technology, but that problem is being worked on from several different angles.

E. CURRENT STATUS OF NETWORK COMPUTING AT THE NAVAL POSTGRADUATE SCHOOL (NPS)

The current state of information technology at the Naval Postgraduate School and the vision for the future are defined in the 'Strategic Plan for Computing at the Naval Postgraduate School' written primarily by Professor James Emery. The Executive Summary concludes that, although the School will become more reliant on

computers and communication networks in the future, "as an institution we are distinctly less than the best. The School will be ill equipped to meet its mission responsibilities going into the next century until major improvements are made."

The eleven technological assumptions that underlie the Strategic Plan provide a realistic foundation for this vision. Essentially, the Strategic Plan is composed of eight elements that provide a basis for defining the information technology environment at the Naval Postgraduate School. The elements are listed below and are addressed in varying levels of detail in the Strategic Plan:

1. The Communications Network
2. The Mainframe
3. High-performance Computing
4. Instructional Applications
5. Administrative Applications
6. Support Services
7. Security
8. Technology Upgrades

A cursory review of these areas reveal that the communications network is the one element that has a direct impact on the entire strategic plan. Therefore, the network should be the organization's first priority. Regarding the current network, the Strategic Plan states, "It would be difficult to find any informed person who would dispute the assertion that NPS cannot achieve its vision for computing with its present network" and that "a contemporary campus network has become essential to achieving the mission of the School and should be as ubiquitous, reliable, transparent,

and easy to use as a modern telephone system." These statements represent an accurate appraisal of the current network, and a reasonable assessment of what NPS should seek in its communications network. Not surprisingly, some of the same challenges that are faced at NPS today are not unlike those that have been encountered at other government agencies in the past. Specifically, Sandia National Laboratories, which will be presented as a Case Study in Chapter IV, faced similar challenges within their organizational communications network. Sandia was able to solve their connectivity problems, enhance the functionality of their entire network, and improve the productivity of their employees through the application of intranet technology.

F. OPPORTUNITY STATEMENT

The connectivity and functionality problems confronting the Naval Postgraduate School are neither new nor unique. These problems have already been addressed and solved in other government agencies and in private industry through the use of intranet technology. Additionally, through the use of an intranet, these organizations have been able to achieve other unanticipated benefits such as increased productivity and efficiency as a result of redefined missions and roles.

Although Internet technology has been around since the late 1960s and early 1970s, its growth really started in 1983 when TCP/IP became the network standard for the Advanced Research Projects Agency Network (ARPANET), which in 1984 became what is now known as the Internet. (Russell & Gangemi Sr., 1991) The TCP/IP protocol is an established, reliable way to communicate. When implemented on a Web-based server behind an organizational firewall, it permits an organization to take advantage of the functionality while extending the useful life of the existing network infrastructure. Economically, intranets became a reality and a viable alternative network architecture within the past year as a result of the growth

experienced in the World Wide Web. Based on Web server and software sales growth, the future of the intranet looks promising despite the relatively nascent software applications that are available today.

What are the greatest benefits that an intranet offers an organization and its users? That answer, of course, depends on the stakeholder's perspective. However, it would probably be safe to assume that the list of benefits would include at least one of the advantages cited earlier in this chapter. Certainly the low implementation cost, ease of use, cross-platform independence, and the openness of this system make it one of the most dynamic and attractive network options available today. But perhaps the greatest advantage lies in the fact that an organization that elects to implement an intranet is getting in on the ground floor of what could be the greatest computer-related revolution to emerge since the creation of computer networks.

G. THESIS OVERVIEW

When starting this thesis, the intent was to first determine the need and feasibility of developing a Naval Postgraduate School 'Executive Contact Management System.' This system would be used by selected staff members to collaborate travel plans and develop agendas when meeting with influential people/entities such as agencies sponsoring research projects.

Next, different software application development tools that could be used to develop a prototype of this system were evaluated. These tools included Commercial Off The Shelf (COTS) products, Government Off The Shelf (GOTS) products, and Rapid Application Development (RAD) Tools such as Delphi Client/Server. Initially, our intent was to only give a cursory look at how this application could be satisfied with emerging World Wide Web technologies. However, we became more and more intrigued at this alternative as we researched the successes being achieved by organizations that had established corporate 'intranets.' In essence, the potential use

of Web-based applications and technology at NPS became the new focus of the thesis. A prototype, Web-based application was developed as an adjunct to, not a central part of, the thesis.

This thesis consists of the following chapters:

- Chapter I. Introduction and Background. Role of intranets and Applicability at the Naval Postgraduate School.
- Chapter II. The Development of the Executive Contact Management System. This chapter details the Web-based application that was developed for this thesis.
- Chapter III. Potential intranet applications at the Naval Postgraduate School.
- Chapter IV. A Case Study. Intranets at Sandia National Laboratories.
- Chapter V. Conclusions and Recommendations.

II. THE DEVELOPMENT OF THE EXECUTIVE CONTACT MANAGEMENT SYSTEM

A. PROTOTYPE SCOPE

Several different hardware and software products were considered for the prototype intranet applications developed as part of this thesis. Fiscal constraints played a big role in limiting the number of products that could be evaluated. Although the tools selected for the prototype represented cutting-edge technology when development started, in six months they were dated with respect to the new tools on the market. This situation reflects the dramatic progress made by both software and hardware developers in this sector of the market.

Because of the fiscal constraint, we focused on those products within our price range that satisfied our needs from both a developer's and a user's perspective. One of the most important criteria in the selection of the development tool was the issue of an intuitive user-friendly product that would promote development, not hinder it. Some of the products we explored were given only a cursory review or were summarily excused because of their complexity. The development team required a flexible, robust system that did not require a large amount of training.

The development tools selected for the prototype may not represent the best tools currently available for deployment in an organizational intranet. Oracle is a more powerful database application than Microsoft Access, which was the database application chosen for the prototype. However, none of the following operating systems or products should be excluded from consideration for a potential intranet application at NPS. Some of these products were too expensive or too technically difficult to master during the development period.

B. PROTOTYPE TOOL SELECTION PROCESS

Some of the different software configurations explored prior to the development of the intranet prototype are described below.

1. UNIX Operating System

- National Center for Supercomputing Applications (NCSA) HTTP Server
- Perl, C, or C++ programming language to build the Back-end, intranet operating system
- Standard Common Gateway Interface (CGI)
- UNIX compatible Data-Base Management System (DBMS)
- Netscape browser

This option was eliminated from consideration primarily due to a lack of visually based tools for the UNIX environment, and the complexity of the required programming languages. DataBase Management Systems (DBMS) for the UNIX operating system are either prohibitively expensive enterprise level systems such as ORACLE, InforMix, and Sybase, or shareware, flat-file, command line based systems distributed free on the Internet. With the cross-platform advantages of an intranet in mind, we also ruled out UNIX for its lack of support for Windows or Macintosh based DBMS products.

2. MS-DOS/Windows 3.11 Operating System

- WinHTTPD shareware (16 bit) Web server
- PolyForm form handling application
- Paradox desktop database
- Windows CGI interface using Borland Delphi as a scripting tool

This was our initial experiment interacting with a database using a Web browser, and it was a success in that we were able to view and add data. The PolyForm application could collect data from a client browser, deposit the data into a CSV text file, and mail a representation of the submission to the DBMS administrator. However, the ability to modify or delete data using this system required extensive programming, and the team was determined to find solutions that did not require programming. Additionally, both team members elected to upgrade their PC operating systems to Windows 95. WinHTTPD, a freeware HTTP Server, would not work with Windows 95 because of some 16 bit/32 bit incompatibilities. However, this problem was solved by O'Reilly's WebSite Web server, which was built exclusively for Windows 95 and Windows NT.

3. Windows 95 Operating System with WebHub

- O'Reilly WebSite Web server (32 bit)
- WebHub Web application development system, which uses Delphi as its programming language
- Paradox desktop database or Interbase by Borland
- Netscape browser

This option was ruled out after the President of HREF Tools Corp held an all day class at the School for a Delphi Interest Group composed of students and faculty. A majority of the class had a very difficult time understanding WebHub at the level required to build a useful Web application. WebHub incorporates extensive Delphi programming into the development process and there is a steep learning curve associated with the product. To further degrade its productivity, WebHub was still in beta testing, and the documentation was cryptic, difficult to understand, and somewhat inadequate.

One of the major advantages WebHub offers is the ability to keep track of a user's interactions with a Web site. The Hypertext Transport Protocol (HTTP) is stateless, which means that it does not keep track of information about a client from one session to another. The stateless nature of HTTP is a problem for sites that must keep track of a user due to security reasons, or to keep track of the items that a user has selected for purchase at a commercial site - the so-called "shopping cart" problem. Netscape and Microsoft have both addressed and solved this problem and now support "Cookies." Cookies consist of a block of information about the client that is stored in the client's browser configuration, and is set remotely by the server. When a client re-connects to a site, the server queries the client's browser configuration for an applicable Cookie. If a Cookie is present, the server configures the session per the instructions contained in the Cookie. This effectively solves the "state" problem for most uses, and nullifies the primary advantage WebHub offers, the ability to save state.

4. Windows 95 With Cold Fusion

- O'Reilly WebSite Web server (32 bit)
- Cold Fusion Web/database application development system
- Access 2.0/Access 7.0 (Win 95) database management system

This combination proved to be the most viable alternative for a "proof-of-concept" prototype because of its cost and the user friendliness of the products. Cold Fusion uses a syntax that is very similar in form to HTML, and can be learned quickly by an average user. It is also very flexible because it incorporates the Open Database Connectivity (ODBC) standard to communicate with any DBMS that makes an ODBC compliant driver. Thus, it scales very well and can be used with Oracle, Informix, and other high-end DBMS products. Cold Fusion also supports the full set

of ANSI standard SQL constructs. Anything that can be done with ANSI SQL can be done with Cold Fusion.

The O'Reilly WebSite Web server was selected because of its ease of use, price, and wide availability. WebSite also runs on the Windows 95 and Windows NT operating systems, which makes it very user friendly and, because of the Windows environment, very widely accepted. The Web server is actually the least important part of the equation. Web servers are built to conform with the open standards of the Internet, and there is little to differentiate the many products now on the market. Microsoft offers its Internet Information Server (IIS) free as part of Windows NT Server package. Internet Information Server comes with ODBC hooks into Microsoft's SQL Server product, which is their enterprise-level DBMS.

Although Microsoft's Access is considered a 'desktop' DBMS, it is actually powerful enough to handle thousands of records without sacrificing performance. Access' ease of use and low price gives it a big advantage over Oracle and some of the other so-called Enterprise Level products in a small- to medium-sized organization. Many small departments that use a desktop database like Access could easily hook their data to an intranet using a product like Cold Fusion. This reinforces one of the advantages of the new intranet paradigm - the owners of the data are responsible for its presentation on the organizational intranet. Access records can be easily scaled up to an Enterprise Level system like SQL Server if the need should arise.

C. PROTOTYPE DEVELOPMENT TOOLS

The prototype was developed using WebSite HTTP server by O'Reilly Publishers, Cold Fusion from the Allaire Corporation, and Microsoft's Access 7.0. The tools can be used with either Windows 95 or Windows NT. The paragraphs below provide a brief technical description.

1. HTTP Server

WebSite is a Windows 95/Windows NT based (HTTP) server. An HTTP server runs on a computer as a background application and listens for HTTP requests on a reserved virtual port. Most Web servers use port number 80 as the default, as does WebSite. When an HTTP server hears a request for a document, it retrieves the document, which is formatted HTML, and returns it to the client browser. The HTTP server also has the ability to serve up inline images, sounds, and video, and may also be used as an FTP file server. The ability to serve up a variety of media, as well as function as an FTP server, makes a web server a very flexible networking tool.

Occasionally a client browser will request that a Common Gateway Interface (CGI) program be run on the HTTP server, and that the output of the program be returned to the client in place of a static document. WebSite can handle three different types of CGI requests: Windows CGI, Standard CGI using PERL or a UNIX based shell scripting language, and DOS CGI, which uses batch files to run DOS programs in the background. Some CGI requests are simple input processing programs used to collect data from a user, as in a survey or questionnaire. Other CGI programs are used to run "back-end" programs such as spreadsheet and database applications. CGI programs can also be used to process input from an image map, which is an image with clickable regions that react differently depending on where the mouse is clicked.

In the event of a Windows CGI request, the server recognizes that a request has come in for a CGI program to be run. Normally included with this request are some parameters such as search criteria or a numerical value to be manipulated. These parameters are passed to the CGI script, which uses them as input to a back-end program. In some cases, SQL queries or stored procedure names and parameters are passed to a DBMS via the CGI script.

The CGI script launches the backend program, and pauses to await the program's completion. Once the CGI script receives data back from the backend program, it formats the data as HTML and passes it to the HTTP server. The server then returns the dynamically generated HTML document to the client browser.

Windows CGI is, of course, supported only by servers that can run under a Windows-based operating system. There are now approximately an equal number of HTTP servers built for Windows NT and Windows 95 as there are for UNIX machines.

WebSite can handle security in two different ways. It can enforce username and password access to a particular directory, or it can exclude by sub-domain. For instance, if the Webmaster wanted to exclude all but the .mil and .gov domains from his or her site, WebSite, as well as most HTTP servers, can provide such a restriction.

2. Web/Database Application Development System

Cold Fusion can best be described as a translation layer that resides between the Web Server and the DBMS. Cold Fusion communicates with the database through a standard known as Open Database Connectivity (ODBC). The following is a definition of ODBC that was obtained from the Microsoft Knowledge Base (MKB), article number Q110093 dated 16 February 1996.

Open Database Connectivity (ODBC) is Microsoft's strategic interface for accessing data in a heterogeneous environment of relational and non-relational database management systems. Based on the Call Level Interface specification of the SQL Access Group, ODBC provides an open, vendor-neutral way of accessing data stored in a variety of proprietary personal computer, minicomputer, and mainframe databases.

ODBC requires three things to operate:

- An ODBC client, such as a Microsoft Access front end, an application created with Visual Basic (Like Cold Fusion), or any other ODBC-enabled applications from other vendors such as Lotus.
- An ODBC driver, which can be supplied by any vendor who chooses to produce one.
- A back-end or server DBMS - Examples: SQL Server, Oracle, AS/400, Foxpro, Access, or any DBMS for which an ODBC driver exists.

Any business rules the developer desires to enforce can be implemented at the DBMS level. Most errors occurring in the DBMS environment can be passed back to the client browser through ODBC. Suppose, for example, that someone entering data in a database via a Web interface tries to add a value that violates a referential integrity constraint. The ODBC sub-system would relay the error description to the Web server, which would then transmit the error to the client browser.

There are also some scripting languages such as JavaScript, a scripting language developed by Netscape that is normally used to tie Java Applets together, and VBScript, which is a similar language founded on Visual Basic. These scripting languages can be used to write small programs that enforce correct data inputs at the browser level, thus unburdening the server and decreasing network traffic.

Cold Fusion was written in Visual Basic, and has an "Industrial Strength" CGI script as its core. The CGI script was programmed by the developers to handle a wide range of tasks related to the interaction with ODBC compliant databases over the World Wide Web. The script is called from the URL string, and is passed the name of a template file that contains the SQL queries, updates, and deletes, and formatting information for the page returned to the user. For example, the URL "http://www.server.web/dbml.exe?template=/thesis/staffsearch.dbm" calls the CGI script dbml.exe,

which is an executable program, and passes the location of the template file, staffsearch.dbm, which contains an SQL statement.

The template files reside on the same physical machine as the Web server, but are isolated from the server because they are outside the server's directory structure.

Only Cold Fusion can access the template files, thus protecting the templates from malicious users. The queries, and other interactions with the database, occur within Cold Fusion, not within the server. The server only sees the formatted HTML code transmitted back to the user. The following illustration should serve to further clarify the process. (CF Users Guide, p. 16)

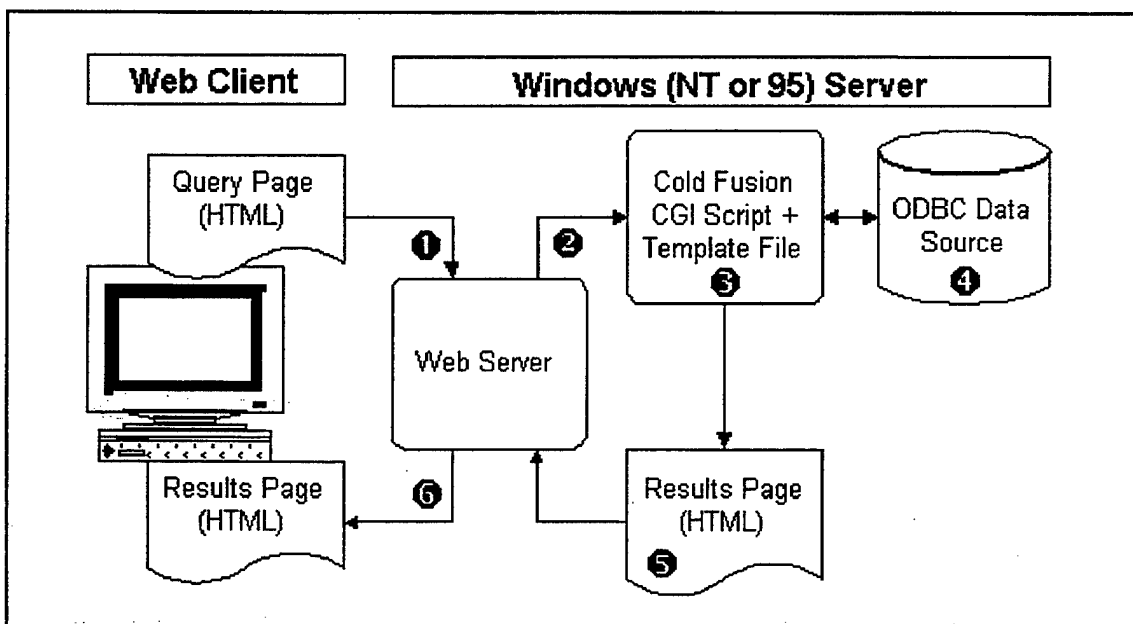


Figure 1. Cold Fusion Logic Flow

1. When a user clicks a "Submit" button on a form or a hypertext link on a page, the user's Web browser sends a request (either a form submission or URL) to the Web server.

2. *The Web server opens a Cold Fusion process, passing it the data submitted by the client and pointing it to the appropriate template file.*
3. *Cold Fusion reads the data from the client and processes DBML commands used in the template, including the type of request to send to the database and the format that should be used to present information to the results page.*
4. *Cold Fusion interacts with the database using ODBC.*
5. *Cold Fusion dynamically generates an HTML page containing the results of the form submission or query and returns it to the Web server.*
6. *The Web server returns the generated HTML page to the user's browser.*

3. Relational Database Management System

Microsoft Access 7.0 - Access is a full featured Relational DataBase Management System that was chosen because of its price, availability, ease of use, and compatibility with both the ODBC standard, and Cold Fusion. The tables were designed and referential integrity enforced with Access, but none of Access' other features were required. The User Interface in the prototype is entirely Web based.

D. PROTOTYPE DEVELOPMENT

1. Introduction to Applications

The intranet applications developed as part of the process of writing this thesis consist of the following:

- NPS Executive Contact Management System
- NPS On-Line Phonebook Prototype

- Faculty On-Line Database Resume (FOLDER) System
- A Threaded Discussion Prototype

Only the NPS Executive Contact Management System (NPS ECMS) will be discussed in any detail. The other projects were developed only for demonstration purposes, and are not significantly different from the NPS ECMS. Appendix B contains examples of the template files used to store SQL queries and formatting information, as well as some screen shots of the NPS ECMS user interface and other applications that were developed.

NPS Executive Contact Management System - This application was developed to permit selected NPS Staff members to provide their input to other Staff members that were scheduled to attend a meeting with a designated influential person such as a member of Congress or a Flag Officer. This would allow the organization to more effectively manage their limited TAD funds. The purpose of the project was to develop an application that would allow the Superintendent and Staff to collect, query, and distribute information about meetings that were scheduled or had been conducted with contacts. The system also permits a user to identify the agenda or topic of a meeting that is scheduled in the future, so that other users can contribute their input prior to the meeting actually occurring. Additionally, the application has several query functions that permit a user to search the database and determine if anyone else has met with that person, or discussed similar subjects in the past.

This was the most complex application that was developed, yet only involved the creation of five tables in Access (Appendix C). The system serves as both a pre-travel and post-travel information system. Prior to departing for a meeting, the traveler enters his or her name, the date, time, and location of the meeting, and scheduled agendas and topics to be discussed. If any other user is curious about the meeting or has other subjects they believe should be addressed, they can Email the

Staff member with this information. When the trip is completed, the traveler enters any other relevant comments or information about the meeting.

The application permits users to:

- Add an instance of themselves in the database and subsequently modify that personal data when it changes.
- Add an instance of a meeting in the database and subsequently modify that data if it changes.
- Record the contacts that attended a specific meeting as well as their own attendance. The input form also contains a field for the user to record relevant comments regarding the meeting, as well as three keywords that can be used to search for specific topics or individuals.
- Query the database to determine who is attending or who has attended a particular meeting.
- Query the database to determine the meetings scheduled or conducted during a specific time period.
- Query the existence of a historical record of meetings that designated Staff members attended.

The NPS ECMS is only a small sample of the wide range of applications that can be developed for use in an intranet. Chapter III will discuss several other possible intranet applications that could be developed using existing technology.

2. Design Goals

The team initially had very little firm guidance as to the requirements. We were told that the Superintendent wanted a method of tracking who was visiting certain high ranking officials in Washington D.C., and the subject of the visits. The original purpose of the application was to eliminate unnecessary or redundant visits, and to ensure that Staff members from NPS knew if anyone had visited that official before. An informal "intelligence system" was needed. Without close interaction

with the potential users, the team attempted to intuit the required functionality. Based on our analysis of the different families of tools available (Web, COTS, RAD, etc.), and the emergence of internal Web-based intranet technologies, it was decided that a Web-based solution would best fit the requirements. The reasons for choosing a Web-based solution are delineated in Chapter I.

The team decided that the Web-based system had to be intuitive, easy to use, easy to setup and maintain, and require little or no training - like a telephone. The Hypertext, "Point and Click" method of navigating information is simple to learn, even for the inexperienced computer user.

3. Design Specifications

Section one discussed very broad design goals for the ECMS project. This section will emphasize some of the detailed specifications the ECMS should achieve.

- The scope of the development is not to be a fully ruggedized, finished product, but a functional prototype that demonstrates some of the advantages of an organizational intranet.
- The system must be entirely database driven. Nothing that can be stored in a table should be hard coded into the HTML forms.
- Functionality will be stressed over the use of graphics, sound, video, and other multi-media features. These "bells and whistles" can easily be added later.
- Drop-down edit boxes populated with data from lookup tables will be used to the maximum extent practical to ensure that mistakes are not made in data entry, and that unnecessary duplications are not made. Hard coding select lists in HTML will not be done.
- Security will be provided to the directory level.
- No information affected by the Privacy Act of 1974 is to be stored in the tables. This includes Social Security numbers, marital status, etc.

- The design will be such that no users manual will be required to operate the system...like a telephone.
- The system administrator should be someone who works near the Superintendent's office, and can be trained in a matter of hours to maintain the database. The ECMS will be designed with this goal in mind. This is in keeping with the spirit of "content creator = content provider."

4. Development Methodology

The methodology was a combination of structured and Rapid Application Development (RAD). A structured methodology was used for the analysis and design of the system, including the design and testing of the tables and queries. The Web portion was developed using a RAD approach.

a. System Analysis

The requirements were defined for us by Professors Emery and Whipple. They gave only general guidance, and empowered us to solve the problem in whatever way we saw fit. We used the PIECES [Whitten, Bentley, and Barlow - 1994] framework to assist in system analysis, substituting our intuition for user input where necessary. PIECES is an acronym that helps break a problem down by what needs improving. The acronym represents:

- The need to improve *Performance*
- The need to improve *Information* (or Data)
- The need to improve *Economics* or control costs
- The need to improve *Control* and security
- The need to improve *Efficiency* of people or machines
- The need to improve *Service*

In the case of the ECMS, the primary areas that needed improving were Information, Control, and Efficiency. Information needed improving because, before the ECMS, there was no system in place to capture information about visits to influential people. Control needed improving for some of the same reasons as Information. The Superintendent wanted some control over how visits to influential people were conducted. Efficiency needed improving due to the need to reduce redundant visits and possibly increase the usefulness of each visit.

b. System Design

Once the team came up with a useful functionality, they began designing tables to track all the entities in the system. Staff, High-ranking Contacts, and Meetings were the major entities. Linking tables were designed to remove some anomalies caused by many-to-many relationships between the major entities.

The tables and queries were designed first, keeping in mind the fact that the database would be hooked to the Web. The design was tested within the Access environment to ensure that the SQL queries returned the expected results. Cold Fusion was then used to hook the tables to the World Wide Web. The team worked on the simple, single table queries first, and progressed to the more complicated, multiple table joins. Appendix C contains a graphical representation of the tables and their relationships.

c. System Implementation

Upon completion of the schema design and normalization, the process of hooking the database to the web with Cold Fusion began. There was somewhat of a learning curve for a few weeks as the team members learned to use the Cold Fusion application, Structured Query Language (SQL), and the Website server. They also had to learn the Windows 95 operating system. None of these subjects was difficult to learn by itself, but integrating them took some effort. One helpful application was

Microsoft Query, which comes bundled as part of the Office Professional suite. The application allows a user to visually build a query, run it, and then cut and paste the underlying SQL code into other applications. Considering that neither of the thesis team members are programmers, these applications presented no significant challenge. An experienced developer or programmer would have almost no trouble integrating Cold Fusion, SQL, and Website.

Printed reports were not specifically addressed in the design of the user interface, although reports can be printed from within the browser. There is really no need to address the issue of printed reports in Web-based applications unless they are specifically requested by the user. In a database driven Web, the information that supports the Web is dynamic and can be readily accessed at any time, thus rendering paper printouts almost unnecessary.

The prototype was demonstrated to Professors Emery and Whipple in April 1996. They made some constructive suggestions that were incorporated into the prototype. For instance, the question of a keyword search on a memo field was brought up by Dr. Emery. It was determined that a memo field, a binary large object (BLOB) field, cannot be indexed and searched. The memo fields in question reside in the "Meeting" table, and contain comments about the meeting. A workaround was implemented by adding keyword fields that can be searched on. The keyword fields are simple text fields that can contain up to 255 characters, and are fully indexed. The owner of the data will have the ability to update the keywords if necessary.

5. Other Application Prototypes Developed

The team also developed some other prototypes for demonstration:

- A database driven faculty resume system (FOLDER) that allows a resume for any faculty member to be stored in a database, built dynamically on request. The resume includes a photo if desired, Hypertext Links to the Staff Member's Email and Web page, and a

description of the Staff Member's interests and areas of research. This system is an extension of a project done in Delphi for a Client-Server class project.

- A searchable phone book prototype. This was done by converting the text-based phonebook that resides on the NPS Gopher server into an Access table, and adding fields for a URL and an Email address. The phone book is searchable by last name, first name, office code, and/or title. For instance, entering an "E" in the last name block, a "J" in the first name block, and choosing "Professor" in the title block will result in everyone whose first name begins with the letter "J", last name begins with "E", and who is a Professor. A test returned the name of Professor James C. Emery. Selecting nothing in the name blocks, and choosing a title instead will return everyone who holds that title - a useful feature if you are looking for the Fire Chief, and do not know his or her name. Selecting an office code such as "SM" would return everyone in the Systems Management Department, which might be a useful feature for a department phone list.
- A simple threaded discussion group that was built with Cold Fusion Forums, which is an add-on to Cold Fusion. This tool allows the simple creation of a guided or un-guided discussion group. Cold Fusion Forums could have been used to create the NPS ECMS. Discussions would be listed in a hierarchical fashion, and would be searchable by keyword. An instance of a meeting would be started as a discussion. A separate utility would have to be used to keep "intelligence" on the influential contacts in Washington D.C.

E. CONCLUSION

The process of building prototype applications was a valuable lesson. It proves that useful applications can be built by an average user using simple tools. Many more tools devoted to intranet and Internet development have been released in just a few months. Java, JavaScript, Browser Plug-ins, Netscape frames, and many other terms were not in use when this thesis was begun. The technology used in building the prototypes for this thesis had to be frozen in place. By the time the documentation of the prototypes had begun, the technology we had chosen was out of date.

Technology is changing so fast that if a developer tries to keep up with the changes by constantly adapting the newest tools and revising his application, he will never complete a project.

As intranet technology matures, the useful life of the tools used to build applications will grow. At this stage in the growth of intranet technology it is certainly beneficial to experiment with as many tools as possible to get a feel for what will work, and what will not.

III. POTENTIAL INTRANET APPLICATIONS AT THE NAVAL POSTGRADUATE SCHOOL

A. INTRANET APPLICATIONS

Web-based applications improve internal communications. This makes users more efficient and, as a consequence, enhances productivity. The intranet applications that can be developed at an organization to improve information flow are virtually limitless, constrained only by the user's imaginations, collective programming talents, and organizational funding limitations. The applications that can be developed, however, can generally be placed into one of three different categories. (Netscape WhitePaper, 1996)

1. Publishing Applications

These applications are essentially one-to-many communication systems where information from a department, section, or workgroup is posted and made available to the entire organization. Applications of this nature are normally static, easy to implement, and often provide the most immediate and tangible monetary savings. These savings normally take the form of reduced production, printing, reproduction, and shipping costs associated with the paper on which the information was previously printed.

2. Transaction Applications

These applications are two-way interactive exchanges such as requesting or providing information to an organizational database. With these applications, the user normally queries a database and in return receives a dynamically populated HTML page with the results of the query. These applications are more difficult to produce than the publishing applications because they normally require some programming. These are the applications that empower users by enabling them to locate information on their own initiative. Transaction applications enhance productivity by removing

the constraints that previously bound individuals to completing request forms or playing telephone-tag with the information source. Information can be retrieved by the user when desired and on demand when distributed using an intranet.

3. Community Applications

These applications are many-to-many, collaborative interactions that facilitate the direct exchanges of information between members in a department, section, or workgroup. This exchange, represents the start of a "thread" that is available for others to review or add relevant information or comments. This thread would be listed in a newsgroup under a subject line, the authors, and an article number and would be available for others to investigate. Community applications are especially effective for project teams that are dispersed throughout a large geographic area but who must still communicate and coordinate their efforts in achieving an assigned project.

Many different applications could be developed and deployed on an organizational intranet at NPS. Information that is currently being conveyed through a paper medium is ideal for migration to the Web-based electronic format of the intranet.

B. APPLICATION DEVELOPMENT AT NPS

Because of its academic mission, NPS is ideally positioned to leverage the talents and energies of its faculty, staff, and students to fully exploit emerging intranet technologies. This is especially true for those faculty, staff, and students associated with the Information Technology Management (ITM) curriculum.

Intranet technology will play an important role in the future of network computing. Since the network at this organization is inadequate, and cannot satisfy our current needs let alone the anticipated ones, why not implement an intranet and develop our own applications internally? The ITM curriculum is very project

oriented. From the first quarter, students are required to collaborate on the development of information technology projects and applications. An intranet would offer an almost unlimited number of potential projects and provide an ideal opportunity for these students to apply their knowledge and expertise on real application development problems. Listed below are some of the possible intranet applications that could be developed at this organization.

1. Plan of the Day

Publish the Plan-of-the-Day on a Web-page instead of using the antiquated white-boards or voice-mail systems that are currently being employed by some Curricular Offices. A Web-site that presents information on a daily basis in this fashion would also provide an online archive not provided by the other two alternatives. Students would be able to access this information at any time of the day or night from any location including their homes. Additionally, a logical extension of this application would also include the School and the Curricular Officer's policies and procedures in HyperText format. Users would be able to easily drill down to discern the various regulations regarding subjects such as leave, liberty, and the Physical Readiness Test (PRT).

Attempts made at NPS to automate information of this nature have not met with much success. For example, the Systems Management (SM) Department's struggle with information distribution has proven futile. In 1994, a student developed an information kiosk as a thesis project that consisted of a 486 computer with a touch-screen. Students can touch the screen in different places to get information about an any number of subjects such as leave and liberty policies, a campus map, staff phone numbers, etc. The kiosk, along with the SM voice mail system, was designed to relieve the staff from routine questions from the 600 students in the department. When the kiosk was first put up, the Curricular Officer instituted a new policy that

messages were no longer to be written on the whiteboards, and that questions would only be answered before 1200, as the staff was too busy doing important work. Students were to refer to the kiosk for answers.

There are several problems with this system. The kiosk is located less than 20 feet from a reliable human source of information. Why would a student take the trouble to learn to navigate his or her way around the kiosk when they only need to know where to drop off a leave request? The room the kiosk is in is locked after 1630, making it useless after duty hours. The kiosk is not hooked up to a network, and is thus not accessible remotely. Worst of all, the kiosk has not been updated since late 1994 when the thesis student in charge of its development graduated and moved on. No one in the SM curricular office knows how to update the information contained in the kiosk.

The kiosk is a good example of a "Stand alone, proprietary, stove-pipe legacy system." Messages are again written on the whiteboards, and the kiosk stands unused. Sadly, the SM department doesn't use Email to communicate with students.

If this information were published on an intranet, and the owner held accountable for its accuracy and the content, there would not be a need for students or staff to redirect their movements in order to read a whiteboard, dial the Systems Management Voice Mail Phone Number for hours on end, or locate a publication that is most likely out-of-date. Information that must be retrieved by making a telephone call or referring to a publication can just as easily be placed on a Web-page and be made available 24 hours a day.

2. School Catalog

Create a Web-site and publish the School catalog on-line. This format would make it available to every student on demand, negate the printing costs associated

with producing it, and allow it to become a living document that is not obsolete by the time it arrives back from the printers.

3. Campus PhoneBook and Email Directory

This application would become another living document that is not obsolete the day it is printed. Hypertext, in conjunction with a product such as Cold Fusion, could provide a robust search function presently not available with a paper version. Information included in the online directory could include section number, curriculum, graduation date, service, or any other public information deemed necessary. Additionally, the Email directory portion of this application would also be in Hypertext format. Clicking on the individual's name would automatically generate the "Mail To" header information of a message to that person.

4. Naval Executive Board (NEB) and Officer Student Advisory Committee (OSAC) Meetings

These forums are of obvious importance to all students, faculty, and staff. Some students are presently receiving these minutes as rather lengthy Email messages. A more efficient method of allowing interested parties to access this information would be to establish a Web-page and provide the URL to the campus - a Pull vs. Push approach. As meetings are conducted, a Hypertext notification would be placed on the main NPS Homepage, 'The Quad,' directing interested parties to the specific meeting. This concept could be extended to any club or organization on campus in a similar manner.

5. Superintendent's Guest Lecturer (SGL) Program Schedule

It would be simple to automate the SGL schedule for the entire calendar year and place it on a Web page. Each speaker's name could be placed in Hypertext format, with a drill-down feature providing his or her biography or links to other sites related to the discussion topic for that day. Unfortunately, unless the SGL speaker is a prominent public personality, such as Dick Cheney, many students are not familiar

with his or her background or their topic until they are introduced by the Admiral. This forum, would alleviate this problem.

Additionally, this application could include an input form where students could submit questions online prior to the presentation. This form could solicit enough quality questions that Curricular Officers would no longer have to prepare and assign questions to students to ask the speaker. Again, this concept could be extended to any speaker that is scheduled to make a presentation. A Hypertext link on 'The Quad' would direct interested students to the location, time, and subject of the meeting as well as a biography of the speaker.

6. Civilian Staff Policies and Procedures

This was one of the first areas recognized by corporations as ideal for migration to an intranet. The Federal holiday schedule, benefit packages, retirement plans, department operating procedures, and training manuals could be placed on Web-based servers so that users could derive all of the benefits this medium offers.

Every employee would now be able to access the most current information available on pages with Hypertext links to a variety of other related topics. These applications would have a profound impact in reducing the production costs presently associated with printing and distributing these documents. A more important benefit, however, would be the satisfaction derived in knowing that the information being provided to your employees was accurate and consistent.

7. Child Care Center

This application would allow parents to observe the behavior of their children enrolled at either the La Mesa Grade School or the Child Care Center and would be contingent upon extending the bandwidth required to transmit and receive quality video transmissions to individual quarters on base. Applications of this nature are already operational at some corporations that provide child care services for their

employees. There is no reason why it cannot be applied to this institution. The ability to transmit and receive quality video on an intranet presents an almost unlimited number of additional applications that could be developed at NPS.

8. Admiral's and Staff Schedule

This information may not be necessary for all students, faculty, or staff, but is important to selected staff and faculty members. Publishing this information online would obviate the need for printed schedules and would provide an accurate schedule that could be remotely accessed. This application would also permit each staff member to identify open periods of time in each other's schedules to coordinate meetings and conferences. Microsoft's Schedule + has an intranet publication feature that can publish individual and workgroup schedules at the click of a mouse.

9. Trouble Desks

This application would permit customers to schedule routine medical and dental examinations, request support from the Audio Visual Department, place work requests with Public Works, or place an order with Base Reproduction through the intranet. Service would become more responsive and customer satisfaction would improve. Customers would be able to place their requests online and no longer encounter endless busy signals or no answer at all from the provider. Additionally, this application would permit service providers to concentrate their efforts on their work instead of being tied up on the telephone fielding routine inquiries.

This application would definitely serve to "flatten" the organization. This fact in and of itself, might result in some institutional resistance that would necessitate a change in organizational culture to overcome.

10. Student Directory

This project is currently under development by another thesis student. As the name implies, it would be a directory that contains information about the students

enrolled at the School. Each record would be established when the student reported aboard and would contain, along with the required personal data, a digitized photograph of that person. This would be a School-wide database that would be available to all offices; as a result, it would preclude a student from having to replicate data such as their name and address at six different locations during the check-in process. Additionally, it would eliminate the redundant data that currently exists in the various stovepipe legacy databases and index card files being maintained within the organization. The standardized fields in the database might include last name, first name, social security number, curriculum, department, email address, telephone number, home address, and Student Mail Center (SMC) number. Obviously, private information such as a student's social security number would not be available for public review.

Since each office has its own unique information needs, each would maintain a table that satisfied its own specific requirements. For example, the Chaplain might require the student's religious preference, Base Police the motor vehicle information, and Public Works any commercial vehicle driving licenses. Each office, then, would be initially responsible for reporting this data and maintaining it.

This intranet application would streamline the check-in process as well as provide more accurate data for the organization by eliminating the redundancy, inconsistency, and the delays inherent in the present processes. Professors would be able to retrieve rosters that include student's photographs in order to put a face with a name. The ad-hoc reporting capabilities for the Registrar or a Curricular Officer would only be limited to their imaginations and the fields they wished to include in their tables. All of the fields in these tables would be encrypted to ensure security. Finally, since the student is the primary stakeholder, he/she would be responsible for

maintaining the accuracy of this common information. An application of this nature could easily be developed for the faculty and staff.

11. 'The Quad'

The NPS Homepage would include Hypertext links to the following organizations and functions: Post Exchange, Legal, Gymnasium, Morale Welfare and Recreation (MWR), and Family Service Center (FSC). These organizations would develop their own homepages that might include information such as the hours of operation, name and telephone number of staff members, and the prices for discount tickets. Additionally, the FSC could offer online versions of all of the literature that it currently provides as pamphlets. In this format, the information would be available and accessible when it was truly needed.

12. Class Schedules and Grades

Distributing schedules and grades is a waste of time and paper. Why not incorporate these processes into the organizational intranet and let students retrieve the information for themselves?

Presently, there is a tremendous amount of time wasted sorting and distributing both schedules and grades to students. These methods are inherently slow because of the manual labor required in the distribution process. With an intranet, when the schedules or grades have been posted to each student's record by the Registrar, an email notification could be forwarded to all students. Students could then retrieve them at their leisure and print a copy if they desire. Because of the privacy associated with grades, there maybe some additional level of security associated with this application. Perhaps another password would be required to access these fields. This process would also eliminate the need for students to complete Locator Card; instead curricular officers could query the electronic record to locate a student.

This application would remove the inherent delays that exist with the current archaic distribution method. Additionally, it would provide students with an online archive of the classes they have completed and their grades. Most importantly, it would permit the staff members that are currently involved in this process to utilize their time in a more productive manner.

13. Leave Request Process

An automated leave request form on the intranet would allow students, staff, and civilian workers to request leave online. This would eliminate the cumbersome completion and routing methods that are required today. Why require an individual to manually route a request form half way around the campus when it can be accomplished electronically? This application would allow individuals to complete an online leave request that would be forwarded to the appropriate approving official. Once through the approving chain, it would be sent to the appropriate administrative office for certification and printing. Individuals could then query the database online to check the status of their request. The application would also provide one centralized database that could be queried to locate specific individuals in the event of an emergency.

14. Employee Bulletin Board

This application could be used by civilian employees to apply for other positions at the School and allow them to submit their resumes online. An application of this nature could also be used as a way of recognizing an employee's achievements and accomplishments. Human Resources (HR) material could be presented in HyperText format with links to other related sites. Changes in policies, procedures, and benefits could also be announced on the main home page with Hypertext links to the specific document that was affected.

Transaction applications could be developed that would allow employees to verify their benefit packages and vacation leave balances on their own instead of being at the mercy of some other employee. This would prevent employees from having to submit requests and having to wait for a response. Additionally, it would free up HR personnel and allow them to work on other more important issues.

Employee-related information of this nature was some of the first that was migrated to an electronic format at the intranets developed at both Silicon Graphics and Sandia National Laboratories. Since these information requirements are fairly universal, well-defined, and standardized, they are ideally suited for electronic publication. This application offers an efficient method of conveying information that is important to all employees.

One interesting application implemented at Silicon Graphics, and frequently monitored by the CEO Edward McCracken, is a forum that allows employees to anonymously express their dissatisfaction or provide a suggestion about a particular event or person. Aside from getting matters that would otherwise remain hidden out in the open, it has the additional functionality of building morale by allowing employees to express their opinions and vent their frustrations. One can clearly see the utility in developing an application of this nature for any organization.

C. APPLICATION GROWTH

Any policy, procedure, or publication that is currently being published and distributed on paper, stands a good chance of wasting valuable government funds. Far greater costs are incurred, however, in lost productivity as employees respond to routine telephone inquiries. These costs could be reduced or eliminated by publishing information and letting users retrieve the information for themselves.

These applications represent the collective ideas of the authors, and provide only a tiny fraction of the possible intranet applications that could be developed and

implemented at NPS. Certainly each curricular office, work section, administrative office, and department also possess a plethora of ideas that would improve information flow through intranet publication. Obviously, with the talent and expertise resident at NPS, there are literally hundreds more applications that could be implemented that would further enhance the productivity of the students, faculty, and staff.

In order for intranet technology to be embraced, certain cultural changes must occur. First, requiring every student, faculty, and staff member to have his or her own computer is not an unreasonable requirement in this day and age. This action would act as a impetus, signaling that, as an organization, we are serious about computing and information technology. It would also fully ingrain the idea of computing into every individual and serve to further the use of this technology.

An IT 'champion' is also a necessity. A champion, as defined by Beath and Ives of SMU, is *"someone who has a vision and gets it implemented by obtaining the funding, pushing the project over hurdles, putting his or her reputation on the line, and taking on the project."* (Sprague, McNurlin, 1993) Both Silicon Graphics and Sandia National Laboratories cited this as one of the primary reasons for the success they have enjoyed with their organizational intranets. These advocates, who had the full support from senior management and the necessary resources to accomplish the change, also spent a great deal of time advocating the use of this technology with the users. Finally, as applications were developed that stream-lined processes and allowed individuals to exercise their initiative, the technology was embraced by the organization. Together, these elements had a synergistic effect in making this technology the network computing standard within these organizations.

IV. A CASE STUDY: INTRANETS AT SANDIA NATIONAL LABORATORIES

A. INTRODUCTION

The team decided that a visit to an organization that had successfully implemented an intranet would be a valuable addition to this thesis. In the relatively short period of time that intranets have been in existence, two organizations have developed intranets that have been consistently recognized in a variety of different articles for both their comprehensiveness and functionality; Silicon Graphics International in Mountain View, California, and Sandia National Laboratories in Albuquerque, New Mexico. Both of these organizations have been on the cutting-edge of intranet development since this phenomena has emerged. But because Sandia National Laboratories is a quasi-governmental organization and therefore more closely represents an organization like that of the Naval Postgraduate School, it, rather than Silicon Graphics International, was selected as the basis for this case study.

A list of questions was submitted to the Intranet Team at Sandia prior to the site visit. These questions provide a framework for this chapter.

B. HARDWARE

1. What types of hardware are used?

Sandia uses one Silicon Graphics multi-processing server for the first two levels of their intranet. There are a total of 106 HTTP servers operating on four networks that are being used by all departments, both internal and external.

2. Is the hardware homogeneous or does it vary widely?

There is some of everything. Some departments use Macintosh for their servers, some use PCS, and some use SUN or SGI machines. The machines with heavy traffic are generally some flavor of UNIX.

3. *Do you differentiate server hardware from user hardware?*

In general, when a machine is being used as a Web server, Sandia does not also use it as a workstation. There are exceptions to this within departments that have low-traffic servers, but the main servers are dedicated to the intranet.

4. *Is a Proxy server used to control traffic in and out of the intranet?*

A proxy server is used as part of Sandia's overall security plan for their intranet. The proxy server controls which sites on the Internet can be accessed by machines internal to Sandia. For instance, Playboy.com is on the list of unauthorized sites. Proxy servers are also used when it is not desired to have TCP/IP installed on all the client machines. This is not the case at Sandia - TCP/IP is resident on all machines.

5. *Does each node in the organization have its own Internet address (IP address)?*

Yes, although access in and out is severely restricted by the firewall and the proxy server.

6. *Are you using any mainframe-based technology in your intranet?*

Yes! Mainframe computers are a central part of the intranet at Sandia. Sandia uses a data warehouse as the foundation of their intranet. The warehouse resides on a mainframe computer running a Sybase relational DBMS. The CIO and his staff currently have no plans to scrap the mainframe. The intranet has actually extended the usefulness of the mainframes at Sandia.

C. SOFTWARE

1. *What server software do you use?*

Sandia uses only Netscape Server products. Netscape supports the widest variety of platforms.

2. *What browser software do you use?*

Sandia's Intranet Team supports only the Netscape browser. Not all browsers will interpret the identical HTML code the same, and the intranet team only designs to the Netscape browser. However, employees may use any browser they choose. So far they have found that no one uses anything but Netscape. The current installation is Netscape 1.2. The Intranet Team is currently migrating to Netscape 3.0, which supports tables, frames, Java, background images, and plug-ins.

3. *What Application development software do you use?*

The head programmer on Sandia's Intranet team developed a "Home-grown" template system using Powerbuilder, which is a Windows programming tool. The system allows users to specify the data they would like to have access to on their portion of the intranet, the queries they need, and the form of the output. The application is very similar to Cold Fusion.

4. *What scripting tools/language (PERL, DOS Batch, WinCGI, home grown, other) do you use?*

Most of the applications built at Sandia use the "home-grown" system. Some applications use PERL, or a UNIX shell scripting language. The team is currently evaluating several suites of development tools, including Cold Fusion. The CIO's philosophy is not to "sacrifice the good for the perfect," and to periodically standardize on one set of tools. The life cycle of development tools is necessarily very short, as new and better tools are released into the marketplace almost daily.

5. *What HTML authoring tools do you use?*

Each author has his or her own favorite. Some authors use text editors, some use HotMeTal by SoftQuad, and some use HotDog HTML editor.

6. *What Document conversion utilities (RTF To HTML, etc.) do you use?*

WordPerfect has a document converter that is frequently used. Microsoft Word's Internet Assistant is also being used, as well as a utility to convert Frame-maker documents. However, most of the conversions from plain text to HTML are completed using a simple editor. This is not to suggest that the Intranet team is doing all the work. The work is spread throughout the departments, and is done primarily by those who desire to have their information made available on the intranet. HTML authoring classes are available to any employee who wants to learn.

D. USERS

1. *What is the single, overriding benefit you have found about the intranet in your organization?*

The most common answer was along the lines of "Universal access to organizational information." Employees are "thrilled" when they see that they have access to almost any information they could possibly want. They also feel empowered by the fact that they can provide information to everyone in the organization. People who used to spend inordinate amounts of time answering the same questions over and over again on the phone are now able to put that information on a web page and get on with their more important duties. According to Fran Current, head of the Intranet Team at Sandia, the people who seem to have benefited the most are the administrative assistants, secretaries, and receptionists. These individuals need access to vast quantities of information and have fairly well-defined information requirements.

2. *Are there negatives? What are they?*

The only negative aspect discussed is also a problem with society at-large. The company has identified a problem with information "Haves" and information

"Have-nots." One-thousand people still do not have their own computers and can not access the information that has been provided on the intranet.

Additionally, some people feel as if they are being left behind when it comes to technology because of their inexperience and fears with working with computers. The Intranet Team is developing a training program to address this issue.

3. *Could you do your job without the intranet?*

Some said "No," and some said "Maybe, but it would be a lot harder, and much less efficient."

4. *Is there any user training? What type? Who gives it?*

Sandia National Laboratory is organized around cost centers. This allows each business unit to more accurately track the resources it uses. If one cost center performs a service for another, they charge for the service. There is an internal Web consulting service at Sandia known as Webco. Webco provides training in browser use to the employees who feel they need the help. They also give a class in HTML authoring, including standards for syntax and an introduction to CGI programming. Webco bills the attendee's department at the rate of \$40.00 per contact hour for each student. An eight-hour class costs the attendee's department \$320.00. Webco also does consulting for those departments who need it or do not want to build their own web pages. Webco bills \$100.00 per hour internally for their consulting services, and they do not lack for work. Webco's charter allows them to keep expanding as long as they can bill enough hours to cover the salaries of the people in their department. Webco employs eight people in total. Some employees work full time, some work part time, giving a full-time equivalent (FTE) of three persons. They plan on expanding as long as they can cover their costs.

E. MAINTENANCE

1. Who maintains the intranet?

The Intranet Team at Sandia, which consists of ten FTE employees, maintains the main server and the top two levels of the intranet. They enforce some standards regarding HTML syntax, but are hands-off when it comes to look and feel, content, and other issues. One of the responsibilities they have is ensuring that all content providers know how to put certain "Meta" information in the header section of an HTML file. The Meta information is used for management purposes, and is explained in part three of this section.

2. Is there anyone responsible for overall content? Look and feel?

The only levels of the intranet that have a common look and feel are the first two levels maintained by the Intranet Team. Each department is encouraged to be creative in the design and content of its own pages. There have been some minor controversies in the area of content. A bicycle commuting group put up a web page about bicycle commuting that met with some protest. Some felt that it was "not professional" and did not belong on the corporate network. The Bicycle Commuter's Homepage stayed on the air, and management is re-thinking their policy about allowing informal postings such as "For sale" bulletin boards and the like. Their feeling is that allowing informal use helps the learning process and can improve morale in the bargain. The only stipulation is that informal Web pages are worked on during lunch or after normal work hours. In order to publish some guidance and clarify issues of this nature, a Content Control Policy was scheduled to be published on 1 July 1996.

3. How are outdated pages tracked and dealt with? Who?

There are almost no tools available to manage widely distributed information as is found on an intranet. Traditional, centralized management techniques will not

work on an intranet. This challenge was recognized early in the development of Sandia's intranet. One of the most impressive "home-grown" applications in use at Sandia is the EveTrak (Enterprise-information Viewing Environment) Database, which solves the distributed management problem. EveTrak captures information about every URL in the intranet by periodically sending out a robot, know as a "Web walker," to parse each HTML page. The Web walker captures information about the page from the Meta tags in the header of the page, and stores it in a Sybase database. Some of the information stored about each page in the system includes:

- URL
- Title
- Review date
- Date last modified
- Size
- Keywords
- Responsible individuals
- Mime Type

The above information is stored in the header of any document published on the intranet. This system is not yet fully implemented, but still works identifying out-of-date documents. In the event a page does not contain the required header information, the Web walker will extract the pertinent dates from the file system.

The creation of these de facto Meta Tag standards may result in one of the largest management problems that the Sandia Team will encounter in the future as it is estimated that only ten percent of the documents that have been published include

all of the required information. In order to correct this deficiency, Sandia is incorporating these standards into the publishing process. The CIO has indicated that only when these requirements becomes part of the publishing process, and that no documents can be published on the intranet without this information, will the organization be able to truly manage the documents on its Web.

4. *Who has authority to decide what goes in and what stays out?*

Each department manager determines what is appropriate for publication.

G. IMPLEMENTATION STRATEGY

1. *Was there an implementation strategy in the beginning? Describe.*

Yes, there was a strategy. Once the decision was made to proceed with a full-scale Intranet, several strategy sessions took place. Employees were questioned to determine their needs, focus groups were held to refine ideas, and review sessions were conducted during each stage of development. The Intranet Team first concentrated on getting the people on the low-tech end of the scale on-board with the idea. This included the Secretaries, Receptionists, and Administrative Assistants as mentioned in Section D above. The On-Line Company Phonebook and Weekly Bulletin were an outgrowth of these focus groups. The intranet at Sandia is very well organized, and did not happen by accident.

2. *What made your organization decide to go with a Web-based intranet?*

Once it was determined that this was the "best, fastest, cheapest, easiest" way to go, it just happened.

3. *Was there a "Champion"?*

Yes. Mr. Fran Current, has been instrumental in getting the Sandia intranet off the ground. His co-workers view him as the single individual responsible for the intranet at Sandia, and that without him it would never have taken shape.

H. CURRENT USES

1. *What are some of the major ways the intranet is being used?*

- On-Line Phonebook that can be searched by last name, first name, partial phone number or name, or Email address.
- On-Line, fully indexed, searchable weekly bulletin that is used to make announcements, distribute new policies, and distribute general information. Starting next fiscal year, the weekly bulletin will not be published in paper form but will only be available through the intranet.
- All policies and directives are on-line and the intranet is the only official source.
- A conference room scheduling program that works "perfectly."
- Customized, current financial reports.
- 40% of company technical manuals now on-line.
- Internal job offerings.
- A classified web that is not hooked up to the unclassified intranet.

I. SECURITY

1. *Is the intranet restricted by domain, password, or combination?*

Sandia restricts by IP address, username/password, and Kerberos security. In addition, there are firewalls and proxy servers to further enhance security.

2. *Do you use an intranet for any type of classified/sensitive work?*

Yes, but that intranet is in no way physically connected to any other network.

3. *Is your intranet, or parts of it, completely isolated from the Internet?*

The only network completely isolated from the Internet is the classified intranet. The rest of the intranet is protected by firewalls and proxy servers.

4. *Can travelers gain access to the intranet? Dial-in, Internet, both?*

Sandia deals in the production of nuclear weapons, and as such is steeped in a culture of secrecy. Management is understandably nervous about allowing outside access. Currently the only service available to travelers is Email, but there are plans to give travelers access to the full intranet in the near future.

J. PLANS FOR FUTURE USE

1. *Is Java's use likely in your intranet?*

At the present time, Java's use is forbidden in the intranet at Sandia due to some well-founded security concerns. Java applets are automatically downloaded from the network and executed on the target machine with no user input. This is cause for concern in the event a malicious program is distributed as part of a web page. JavaScript, which is not an executable program is used in some of Sandia's intranet.

2. *Do you plan to migrate to any other kinds of software?*

Several new tools are currently being evaluated.

3. *What are some of the uses being developed now?*

An on-line training program was demonstrated during the visit. It will be used to fulfill annual training requirements for sexual harassment, environmental health, industrial hygiene, safety, and similar subjects. The format is 'edutainment,' and is highly interactive. The employee will be automatically notified via email when an annual training requirement has expired. They can then sign up for the training, including on-line quizzes, and conduct the training at their leisure within a prescribed time-period. Normally, users will have two weeks to complete the training from the date it was initiated.

K. RETURN ON INVESTMENT

1. *Has return on investment been quantified in any way?*

(Paper savings, phone calls, publishing costs, travel, mailing costs) Not in any rigorous, formal way. Paper savings alone have saved hundreds of thousands of dollars.

2. *What methods were used to quantify ROI?*

Some direct savings such as paperwork, some distribution costs, wasted time, etc. "We have been too busy doing it to take time out to quantify it" was overheard. There are plans to try and quantify it toward the end of this year (1996).

3. *If not, how have you determined that an intranet has been worth the investment?*

It has transformed our organization.

L. ADDITIONAL COMMENTS

The scope and functionality of the intranet implemented at Sandia National Laboratories is very inspirational. This is especially true considering how much has been accomplished in a relatively short period of time. Sandia's intranet, and the applications that have been developed for their intranet, have solved many of the same types of computing related problems currently facing the Naval Postgraduate School, and delineated in 'The Strategic Plan for Computing at the Naval Postgraduate School.' First and foremost, however, it solved their connectivity problems, permitting the free flow of information between organizational members. If culture can be defined as "the way we do things around here," the intranet at Sandia has certainly played a major role in re-inventing their organization.

The communications network at Sandia is as diverse and "patched together" as the network at NPS, and is additionally encumbered by three times the number of clients. Once the decision to implement an intranet was made by senior management,

directives were issued that in effect said "Get on board or get out of the way!" Programmers familiar with the mainframe environment were forced to learn C++ and HTML. Change was universal and became an accepted fact of life in the Information Systems Department.

Sandia was successful in their intranet development because employees were able to embrace this change. Second, the organization had an intranet champion. Third, this champion had the authority to assign the "best and brightest" to this endeavor. Fourth, management devoted the resources necessary to the development effort. Finally, the champion and his disciples, evangelised on the use of this technology until the intranet took on a life of it's own.

The Naval Postgraduate School could learn a lot from Sandia's intranet development experience. Sandia has proven that an intranet can be an integral part of any reinvention effort.

V. CONCLUSIONS AND RECOMMENDATIONS

A. CONCLUSIONS

Intranets are certain to play an integral role in the future of organizational network computing. The migration to World Wide Web technology in internal networks is not a passing fad. Users of the Web are driving the development of intranets. People find it strange that they can go on-line and find obscure information such as the average birth weight of a Rhode Island Red Rooster from a farmer's computer located 2000 miles away, but cannot find out information about their own organization's dental plan on the company network. Advocates for intranet technology come from the growing legion of experienced Web Surfers. When they see the type, quantity, and quality of information available on the Web, they ask "Why can't we do that within our organizational network?" The answer is that they can, and should.

Every "Paradigm Shift" in Information Technology has occurred primarily as a result of users demanding access to, or control of, data. Operators of mainframe computers in the 60's and 70's were the sole keepers of the data. To get anything out of a computer, you had to ask the guys in the "Glass House." As minicomputers became more prevalent, departments began to demand control of their information. Accountants wanted control of their financial data; the Marketing department wanted access to, and control over, their marketing information; and CEOs wanted the ability to retrieve their own reports. When Personal Computers entered the business world, the rush to own data intensified even more. Users have always been the impetus for new and better technologies which has resulted, not surprisingly, in even more access to data and information.

The Intranet Team at Sandia described their data warehouse as "one big, accessible, glass house full of data." In this case, however, the glass house did not mean the air conditioned, controlled access rooms where mainframes were once maintained. It meant that everyone has access to any data they could possibly use.

Why intranets make sense:

- Intranets get the right information to the right people at the right time.
- Intranets are as easy to use as a telephone.
- Intranets provide Universal Access; everyone can get to the data they need.
- Intranets can coexist with other Network Operating Systems (Novell, Banyan, Microsoft, UNIX, etc.).
- Intranets extend existing infrastructure and provide easy access to legacy data.

B. RECOMMENDATIONS

Companies are embracing intranets for many reasons but, in its most simple form, intranets make information available to those who need it, the users, at minimal incremental cost. The Naval Postgraduate School is ideally positioned to fully leverage this emerging technology. Intranets offer an ideal solution to some of the connectivity problems that currently confront this organization. They also appear to be able to satisfy the anticipated challenges of tomorrow. In order to successfully implement this technology, however, this institution must first take some specific steps. Listed below are some of the more pertinent points that need to be addressed during the planning and implementation stages of a Naval Postgraduate School intranet initiative.

- Leadership intranet technology must be embraced by the highest levels at NPS. One of the most important lessons that we have learned from both Silicon Graphics and Sandia National Laboratories is that these advocates are essential.
- Next, an Intranet Implementation Task Force should be formed to manage the development and implementation efforts. This Task Force should develop a realistic, achievable timeline for this implementation. Additionally, the task force will need to address the following issues.
 1. A thorough review must be conducted of the positions, roles, and functions currently being accomplished by the IT personnel presently employed by this organization. This review must consider these positions with respect to this new technology. Unnecessary and unwarranted positions must be eliminated and new positions created where necessary to support this effort. No more than six to eight full-time employees should be required at the outset. These numbers are based on staff currently responsible for the intranets at Sandia National Laboratories and Silicon Graphics - ten and six, respectively. Additionally, training programs must be initiated to teach the IT staff new intranet development languages as well as the technological requirements of this new network standard.
 2. The following questions should be answered by the Task Force: Should a commercial vendor such as Silicon Graphics be hired, or should all development be internal, employing in-house assets as was done at Sandia National Laboratories? Is the best approach a combination of both commercial and internal assets, including the integration of students from the ITM and CS curriculums?
 3. In order for this technology to be embraced by the masses, two or three of the first applications developed should have an immediate and lasting impact on the members of this organization. The student directory, on-line leave request form, and making students' grades and schedules available on the intranet are three potential applications that would affect almost

every member of this organization at least weekly and perhaps even daily.

4. As interest in this technology grows, training and classes must be available to instruct those sections, departments, and personnel interested in developing a Web presence. This training is an essential element in nurturing robust, useful, user developed applications.
5. Intranet growth must be thoroughly planned and managed, and whenever possible management tools should be incorporated. As mentioned earlier, only ten percent of the documents on Sandia's intranet contain all the required meta-information needed for proper administration. This situation poses a potentially serious management problem. NPS can certainly learn from the mistakes and oversights of others and build mechanisms into our processes to prevent similar occurrences. Any new technology must be managed and intranets are no exception.

Intranets may not be the ultimate networking solution; surely a better and even more functional technology will be developed in the future. However, they do represent the most useful, cost-effective networking solution today and for the foreseeable future. Considering the immediate benefits and the low cost of implementation, any organization that has an existing network infrastructure should consider an intranet.

APPENDIX A. GLOSSARY OF TERMS

CGI (Common Gateway Interface)

An interface standard that allows Web servers to run external applications.

Cold Fusion

A database application development tool that enables the rapid creation of interactive, dynamic, information-rich Webs.

DBML (DataBase Markup Language)

A set of constructs used by Allaire's Cold Fusion product that defines and controls access to ODBC databases over the World Wide Web. DBML is similar in form to HTML.

Firewall

A hardware or software barrier between a private network and the public Internet or other networks.

FTP (File Transfer Protocol)

An Internet based protocol that allows a user on one computer to transfer files to and from another computer.

Groupware

Applications such as Lotus Notes that allow users to share information and work together.

HTML (HyperText Markup Language)

The document formatting language that underlies most World Wide Web pages. It can be used to format text and link to images, audio, video, and other programs such as Java and CGI applications.

HTTP (HyperText Transport Protocol)

The Internet based protocol that negotiates the delivery of WWW documents and applications.

HyperText

Text that is highlighted and represents a link to another resource. That resource could reside on the same computer, or one on the other side of the world. Hypertext allows real-time, non-linear access to network resources.

Intranet

An organizational network that uses World Wide Web technology and standards.

Java

An object-oriented language developed by Sun Microsystems. Java is used to write platform-independent applications that can be distributed over the World Wide Web.

ODBC (Open Database Connectivity)

Open Database Connectivity (ODBC) is Microsoft's strategic interface for accessing data in a heterogeneous environment of relational and non-relational database management systems.¹

Perl (Practical Extraction and Reports Language)

A language that can be used to extract and process input from World Wide Web forms.

Replication

The synchronization of data residing on two or more computers.

S-HTTP (Secure HTTP)

An extension of HTTP for authentication and data encryption between a Web server and a Web browser.

SSL (secure sockets layer)

A transport-level technology for authentication and data encryption between a Web server and a Web browser.

TCP/IP (Transmission Control Protocol/Internet Protocol)

The collection of transport and application protocols used to communicate on the Internet and other networks.

¹Microsoft Knowledge Base (MKB), article number Q110093 dated 16 February 1996.

URL (Uniform Resource Locator)

A string of characters that identifies the location of an Internet resource.

Web Server

A HyperText Transport Protocol (HTTP) server that provides Internet resources. The HTTP server has the ability to serve up text, inline images, sounds, and video, and may also be used as an FTP file server.

APPENDIX B. ECMS TEMPLATE FILE AND USER INTERFACES

This appendix contains a copy of one of the template files used to execute a query in the ECMS. Examples of the ECMS user interfaces, as well as the interfaces of the other intranet applications developed as part of the thesis are also provided.

```
<DBQUERY NAME="FindStaff"
    DATASOURCE="Thesis"
    SQL="SELECT      *
    FROM              Staff, Meet, StaffMeet
    WHERE             StaffMeet.StaffID = Staff.StaffID
    AND               StaffMeet.MeetID = Meet.MeetID
    AND               ((StaffMeet.MeetID=#MeetID#))
    ORDER BY         Staff.LastName">
<HTML>
<HEAD>
<TITLE>Contact Management System</TITLE>
</HEAD>
<BODY BGCOLOR="#669999">
<CENTER><H2><I>Contact Management System Query Results</I></H2></CENTER>
<HR WIDTH=100% ALIGN=center SIZE=10>
<PRE>
<PRE>
<DBIF #FindStaff.RecordCount# is 0>
<H3>Sorry! No StaffMembers in the Database attended that Meeting.</H3>
<DBELSE>
<DBOUTPUT QUERY="FindStaff">
First Name:<STRONG> #First Name#</STRONG>
Last Name:<STRONG> #LastName#</STRONG>
Email Address:<STRONG> <a href="mailto:#EmailAddress#">#EmailAddress#</a></STRONG>
Office:<STRONG> #Department#</STRONG>
Notes:<STRONG> #Notes#</STRONG>
</DBOUTPUT>
</DBIF>
</PRE>
</PRE>
<HR>
<H2>Hope this information is Helpful.</H2>

<A HREF="/Index.html">Return</A> to the CMS Main Page.<P>
</BODY>
</HTML>
```

This template file executes the "FindStaff" query and identifies the Staffmembers that attended a specific meeting or conference. The results of the query are generated "on the fly" and provided to the user in HTML form in the "FindStaff" DBOUTPUT section.



Intranet Projects

- NPS Executive Contact Management System
- FOLDER Project
- Intranet Conference
- NPS Phonebook Experiment
- Long NPS Phonebook Experiment
- EMETRAK Project
- TROUBLE Desk

Other Places

- NPS Homepage
- Marines Homepage
- Browse the Thesis

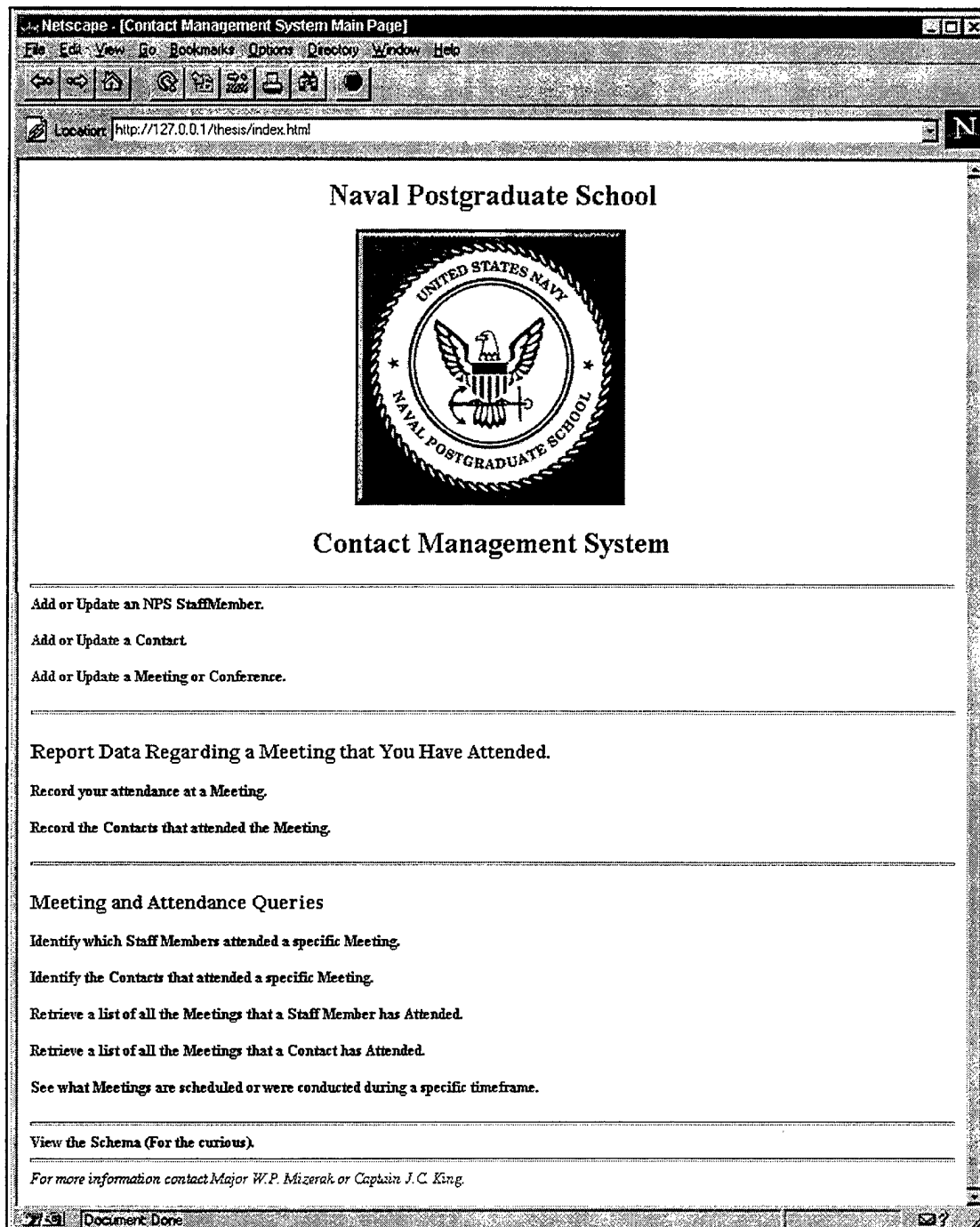
You are visitor number 425.

Mail: J.C. King

Last Updated: Saturday, July 6, 1996

7/5/96 Document Done





Netscape - [Record Meeting Attendance]

File Edit View Go Bookmarks Options Directory Window Help

Location: <http://127.0.0.1/cgi-shl/dbml.exe?Template=Thesis/InStVip.dbm>

Use this form to record your attendance at a Meeting or Conference.

First, click on the name of the Meeting that you attended and then click on your name in the second box. Next, place the cursor in the 'Meeting Notes' box and record any comments regarding the meeting that you want included in the database. Finally, click on the 'Record Attendance' Button to submit your input.

Select the Meeting that you attended below

The meeting 1996 BRAC Meeting was held in Ft Ord on 960201.
The meeting 5th Bn, 10th Marines was held in San Diego on 960302.
The meeting Ada was held in Albany, NY on 960102.
The meeting Aircraft Carriers was held in Washington DC on 960403.
The meeting Battleships was held in Baltimore on 960505.

Select Yourself

Gomez Adams from the Computer Science Department.
Rick Anderson from the Physics Department.
Joe Barnes from the Dean of Instruction Department.
Frank Barrett II from the Dean of Computer & Information Services Department.
Samual Bead from the National Security Affairs Department.

Meeting Notes

Put Your Comments Here.

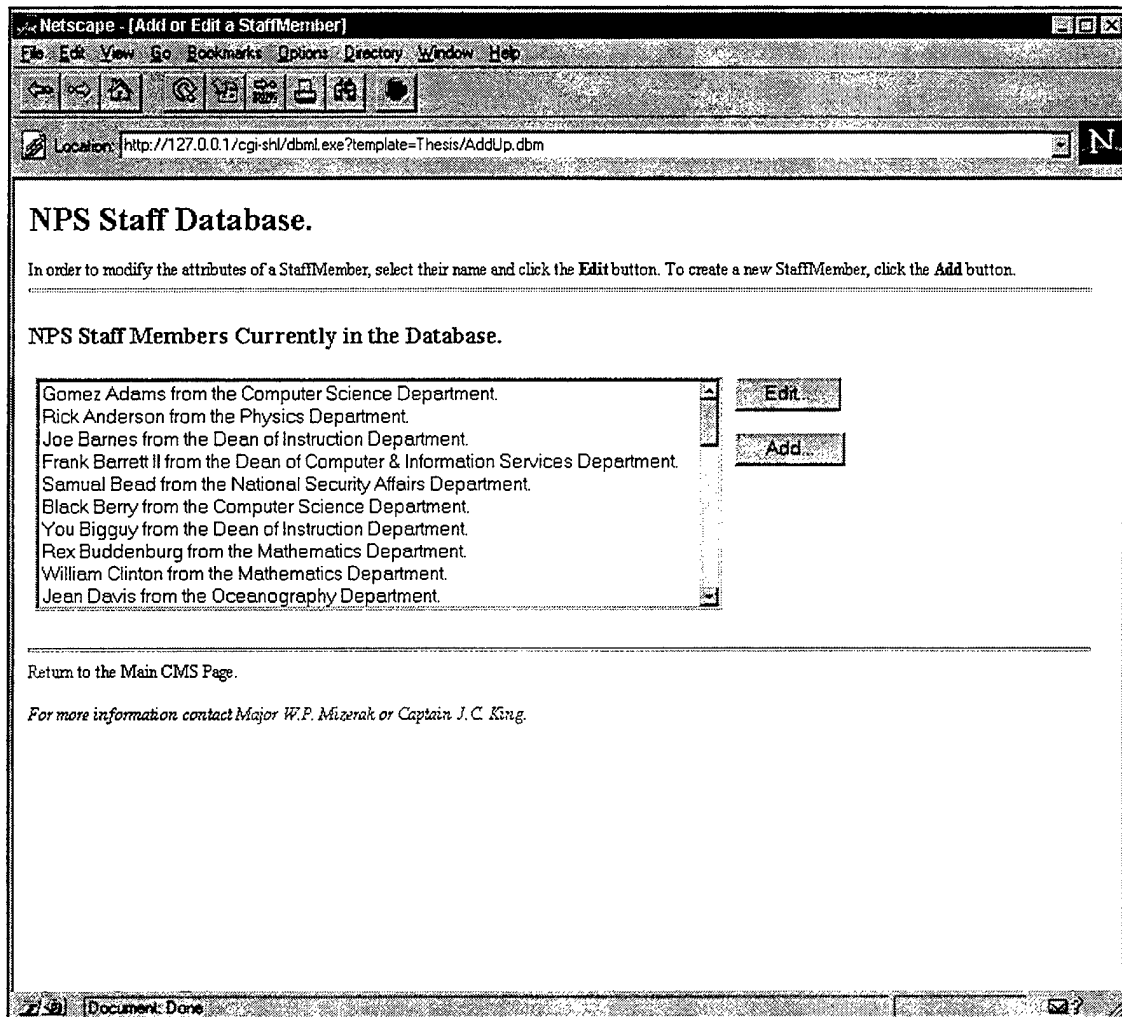
Record Attendance

RESET Pressing this button will only erase the previously recorded 'Meeting Notes' comments.

Return to the Main CMS Page.

For more information contact Major W.P. Mizerak or Captain J.C. King.

Document Done



Netscape - [Edit a StaffMember]

File Edit View Go Bookmarks Options Directory Window Help

Location: http://127.0.0.1/cgi-shl/dbml.exe?action=query&template=Thesis/Updat.dbm

Edit Staff Member Record.

Place the cursor on any of the fields that need to be edited and make the appropriate change. When completed, click the 'Update Record' Button to record those changes in the database.

Joe Barnes

Last Name:

First Name:

Work Phone:

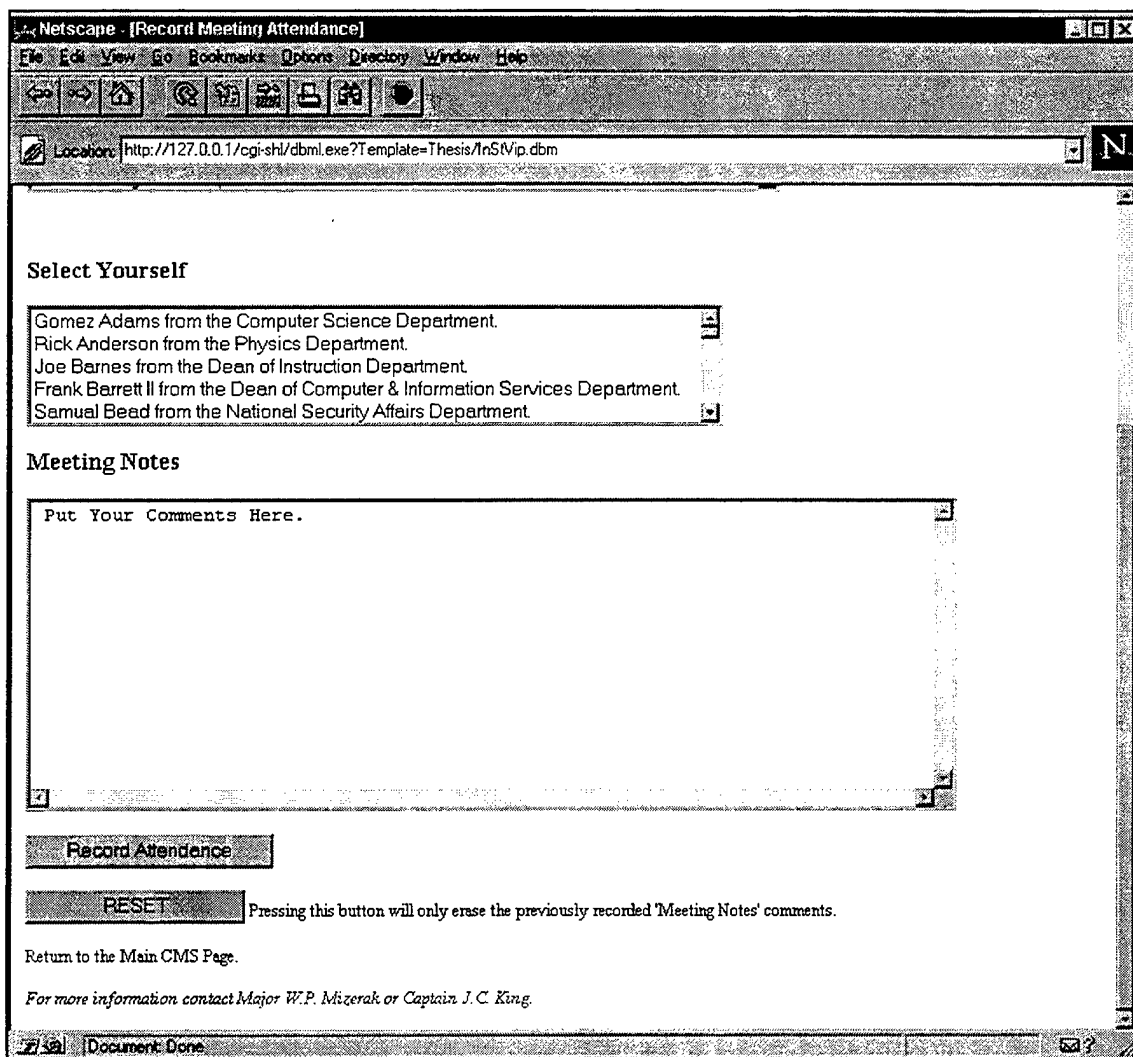
Email Address:

Department:

Return to the CMS Main Page.

For more information contact Major W.P. Mizerak or Captain J.C. King.

Document Done



Netscape - [Contact Management System]

File Edit View Go Bookmarks Options Directory Window Help

Location: <http://127.0.0.1/cgi-shl/dbml.exe?template=Thesis/MeetAdd5.dbm>

Contact Management System Query Results

Meeting:	Aircraft Carriers
Meeting Agenda/Topic:	Keeping squids from crashing into the fantail
Location:	Washington DC
Start Date:	960403
End Date:	960415
Comments:	The number of yards of flight line was discussed at this meeting

Meeting:	EMP
Meeting Agenda/Topic:	aaa
Location:	Hartford
Start Date:	960203
End Date:	960203
Comments:	EMP is my LIFE!!!!

Meeting:	Go carts as a Nuclear delivery vehicle
Meeting Agenda/Topic:	Looking into the possibility of having a monkey drive a 4WD go cart with a 6kt yield weapon behind enemy lines and self detonate the weapon. Issues: Animal Cruelty Monkey goes berserk
Location:	Pentagon
Start Date:	960601
End Date:	960603
Comments:	I was very impressed by the presentations, but I feel sorry for the poor monkey.

[Return to the CMS Main Page.](#)

For more information contact Major W.P. Mizerak or Captain J.C. King.

Document Done

Netscape - [Generic Trouble Desk]

File Edit View Go Bookmarks Options Directory Window Help

Location: http://127.0.0.1/guestfm.htm

Welcome to the Naval Postgraduate School Trouble Desk

Your submission will be E-mailed to the trouble desk and placed in an HTML file for historical purposes.

Please enter your Name:

Please enter your E-Mail Address:

Please enter your Phone Number:

Please enter a detailed description of the trouble you are having:

Housing: My dishwasher is broken

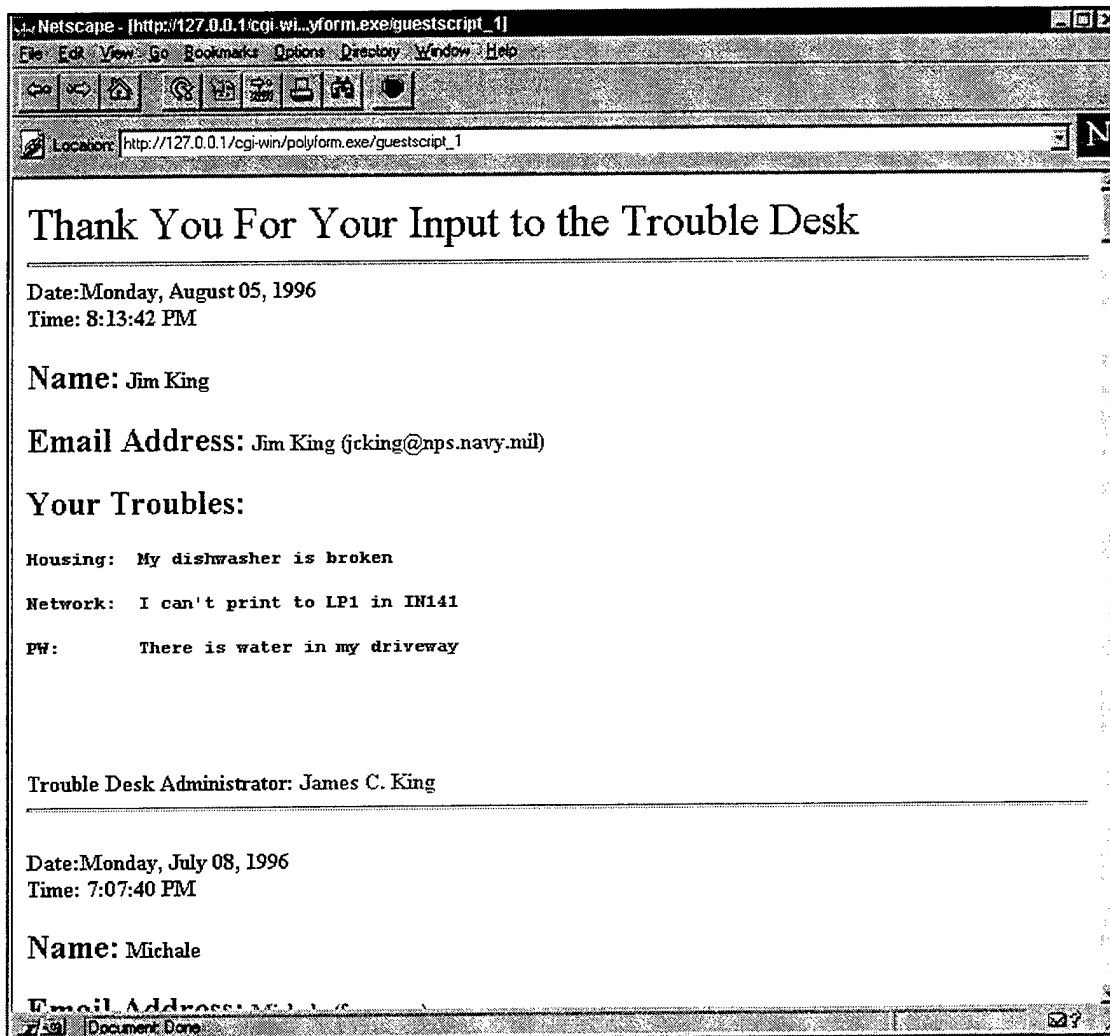
Network: I can't print to LP1 in IN141

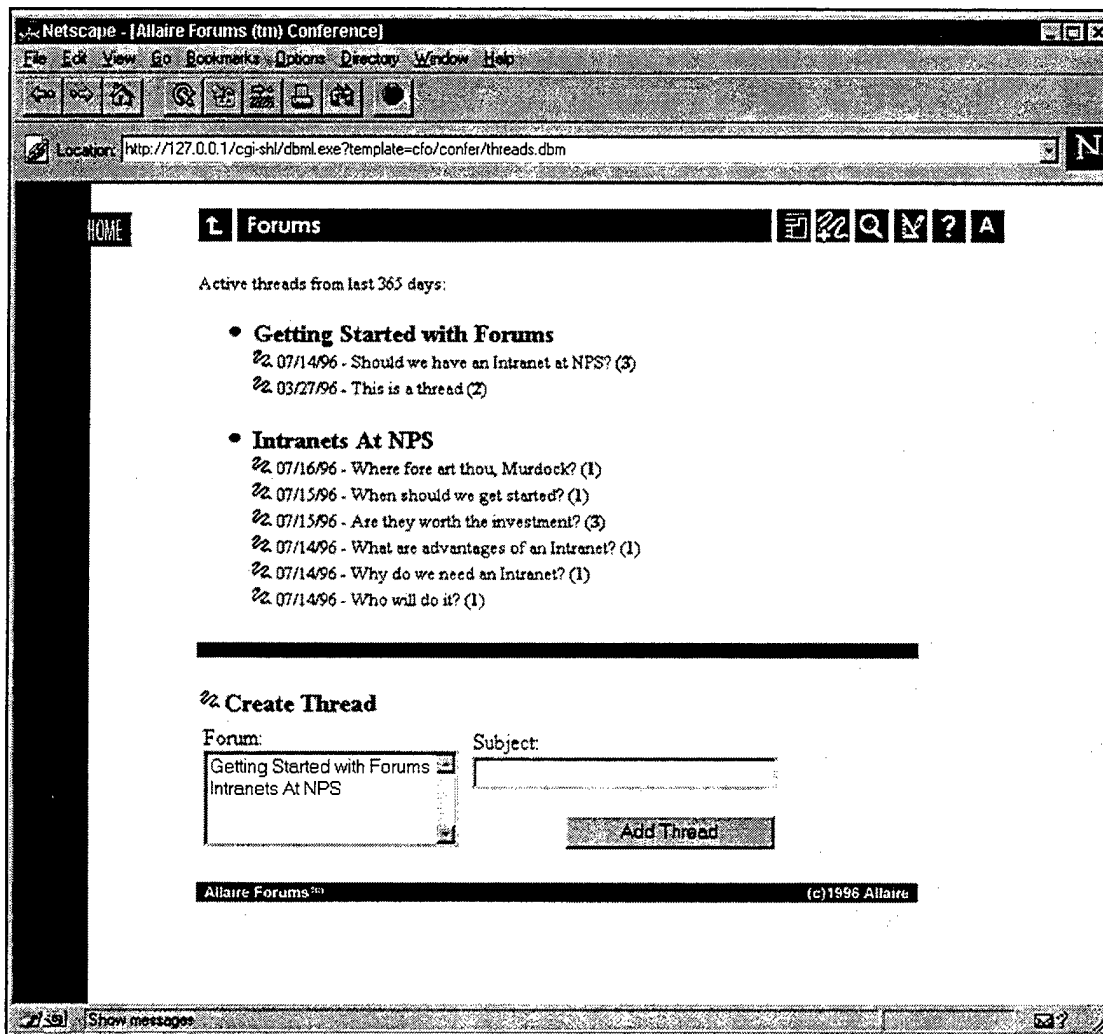
PW: There is water in my driveway

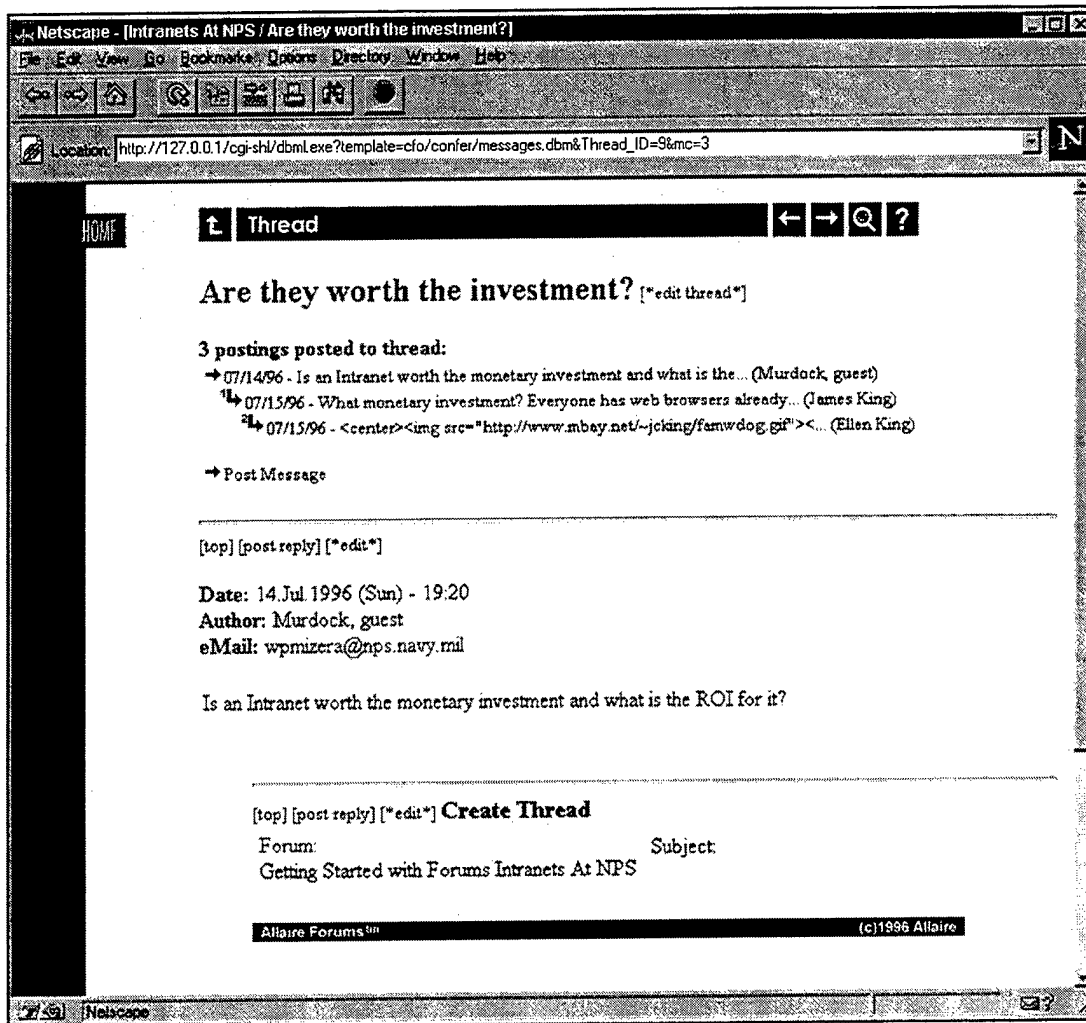
To submit the form, press this button:

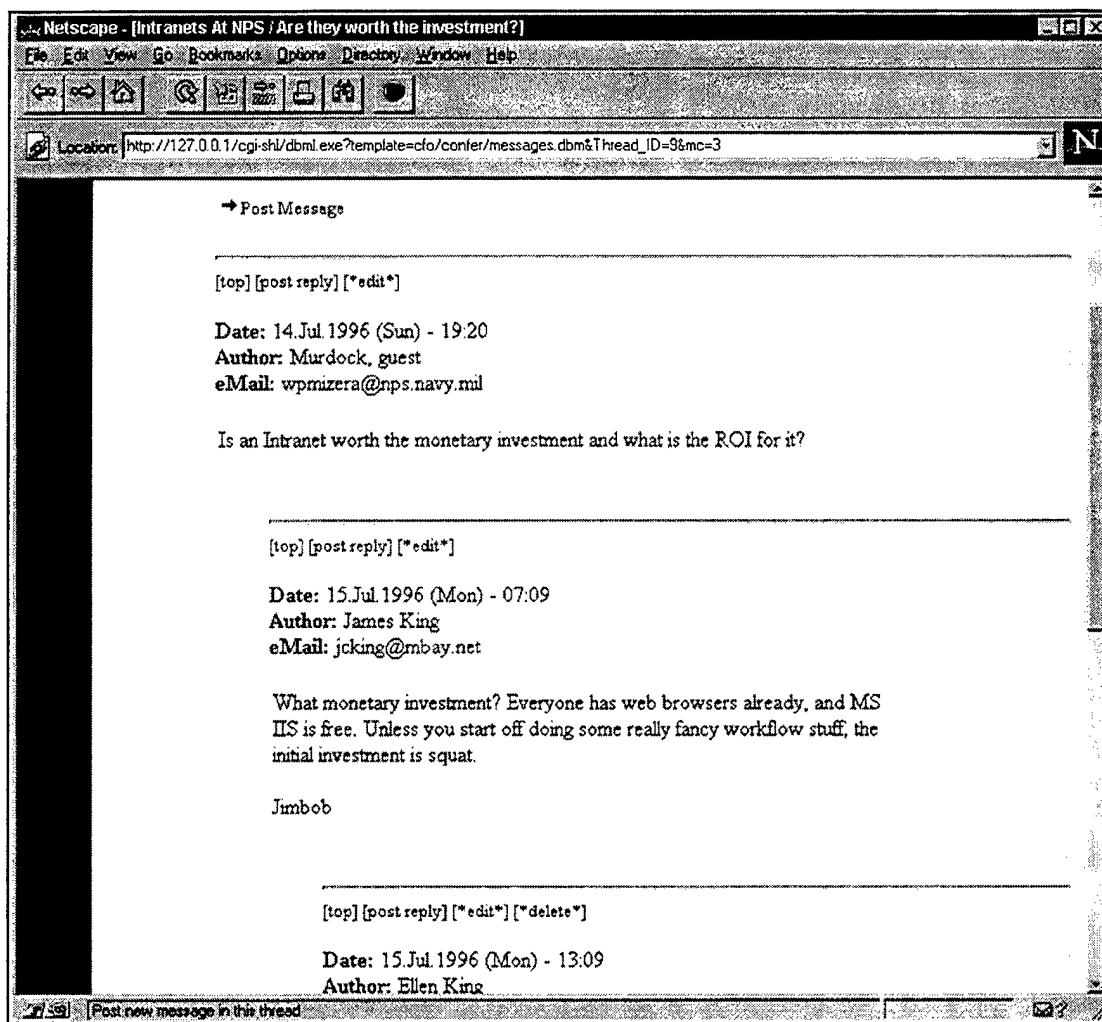
To clear the form, press this button:

Document: Done

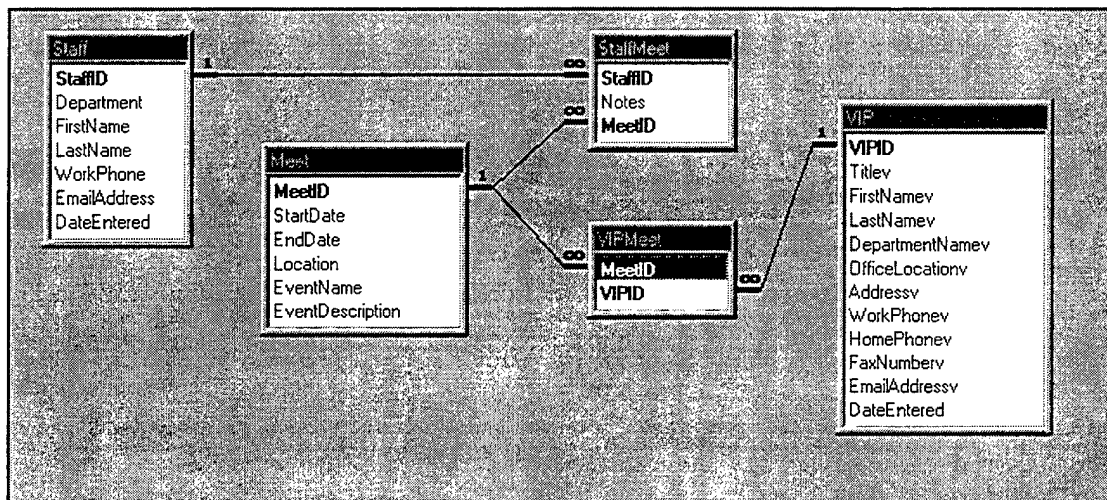








APPENDIX C. TABLES AND RELATIONSHIPS FOR ECMS



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